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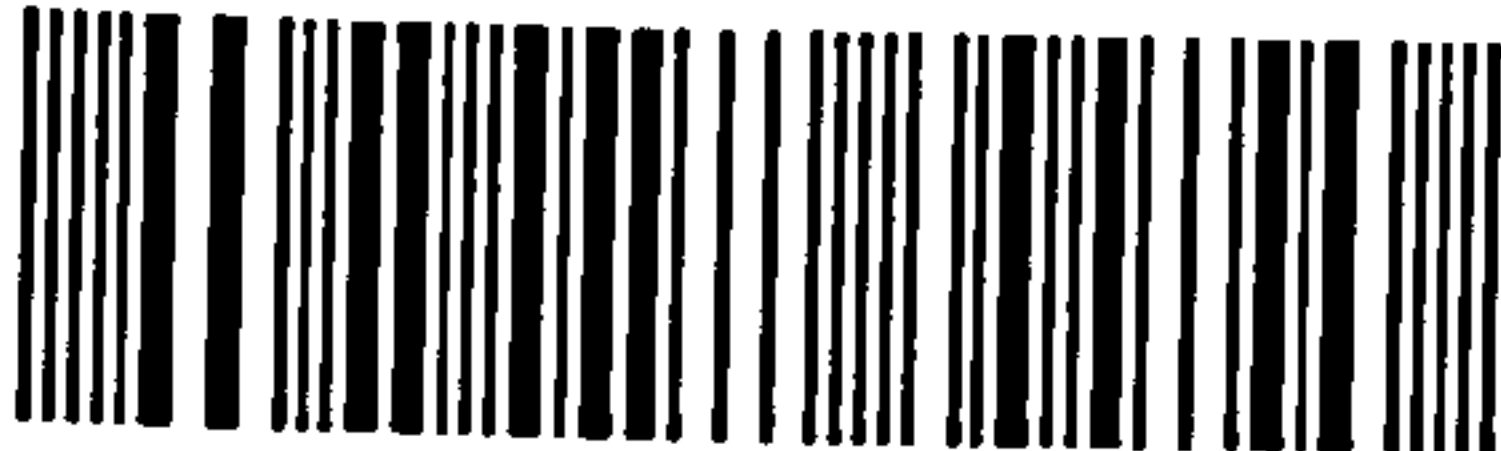
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Investigation Into the Design of Educational Multimedia: Video, Interactivity and Narrative

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Abstract

Investigation Into the Design of Educational Multimedia: Video, Interactivity and Narrative.

This study critically examines the design of multimedia in education. The study begins by reviewing existing media in education and then uses a series of empirical studies to uncover, and then examine the key issues for the design of educational multimedia.

The research involves two studies. The first, a preliminary study, that identifies specific areas of interest for the research. This study looks at the existing use of an interactive video disc program for training in Price Waterhouse. The literature search, combined with the outcomes of the preliminary study, identified the areas for further research as: the use of video, forms of interaction, and the role of narrative. The main study examines these areas using two phases. The first phase analyses three treatments of the same educational text, on linear video, multimedia, and structured multimedia, each treatment maintaining the same content and narrative structure, but differing in presentation and control. The second phases builds on the results of the first with the creation and analysis of an interactive multimedia program that takes advantage of the identified strengths of multimedia, and specifically tackles problems found in the first phase. Qualitative data collection techniques are used in both phases, and form the basis of the findings.

The findings are presented as implications for multimedia design, and discuss the use and development of narrative and grammar in multimedia, as well as the importance of carefully designed user interaction and goal definition.

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Chapter 1 : Introduction

1.1. Video in Educational Multimedia

There has been a lot of interest, recently, in multimedia, both from technological and educational perspectives. This chapter will briefly examine both perspectives in order to demonstrate the motivation for the questions this thesis examines. The latter half of this introductory chapter is a chapter by chapter guide to the organisation and approach of the thesis.

Multimedia has great potential - this new technology contains many ways of representing an educator's argument through its component media. It can provide sound, photographs, diagrams, text, video, animation, music. It can tell stories, play games, ask questions, provide answers, process data. Multimedia has created a lot of excitement in both the computer industry and in education, but there is also a certain amount of scepticism. As Chen observed of interactive video (IV) the capabilities of the media do not automatically make a successful medium for education:

whether it is a real panacea or not, the IV does not contain within itself an assurance of effective use in education. It can just as easily be used in trivial or ineffective ways. Chen (1990; p5)

Educational effectiveness does not depend on the medium but on how it is used. To be used effectively the designers of multimedia need to know more about the nature of the medium and about how learners are able to use and interpret it.

1.1.1. A short technical history of multimedia

Multimedia is the (ideally) seamless integration of text, images, graphics, animation and video under computer control (Jacobs, 1992). It is not just the instant availability of each of these forms of representation to the user that makes multimedia interesting, but the fact that they are controlled by the computer. The computer control makes it possible for a system to respond to the learners - adapting to their progress, answering their questions, providing feedback to their answers and guiding them when they are unsure. This section traces a brief history of multimedia.

Perhaps film can be described as the first multimedia medium. It is certainly multimodal in that it brings moving pictures and sound together. A new grammar, and indeed a whole new culture, had to be built around film. This is one of the reasons why this thesis, in its discussion of multimedia, will draw so many parallels with film and video.

Educational courses using a variety of media are not a new thing. Since the 1960s, the British Open University has been producing distance learning courses which are not only print based, but include audio, video, and more recently computer assisted instruction (CAI). Initially the OU broadcast audio visual material as either radio or television. Shrinking transmission slots and a growing understanding of the use of these media in education facilitated a move to cassette based rather than broadcast media. Because of the availability of cassette players audio was the first to make this move. Research showed learners found audio material on cassette twice as valuable as identical material broadcast on radio (Durbridge, 1981). Tapes were designed to take advantage of the control users have over them, the tape could direct the learner to pause it and carry out some task, the tape then providing feedback that the tutor anticipated the learner would need. The control allowed the learners to pace their work as the audio leads them through some activity, and Durbridge (1984) finds that such techniques increase the involvement of the student in the work:

The effect of such teaching strategies was said by the students to create the sense of a piece of co-operative learning; the interactivity they encouraged appeared to be seen not just as between the student and hardware, but between student and teacher. Durbridge (1984; 229)

Similar use of video cassettes in Open University courses became viable more recently, now that the university can reasonably expect its students to own or have access to a video player. Research (Laurillard 1984a, Durbridge 1984) does show similar types benefits for user control of video cassettes as for audio cassettes. Video though is much more complex than audio (audio forms only a part of video after all) and consequently the issues involved in providing learner control are also more complex, these complexities are discussed in the next chapter.

The role of computer graphics in multimedia must not be over looked. Computer graphics have come along way from the 16 colour CGA graphics cards of only a few years ago. High resolution screens displaying millions of colours (24 bit) are fast becoming common place. The advance in graphical capabilities has been linked to the increasing power of computer processors needed to process and store them. Display quality (resolution, colour depth, and display and update frequencies) has almost matched the limits of human vision, improvements beyond this would require some special purpose.

Booth (1994) looks into the future of computer generated graphics in the light of recent attention to the captured graphics of multimedia. Despite ever increasing computer power enabling 3d graphics to be generated in real time Booth sees the ease of using and manipulating existing images resulting in less reliance on real time generated images, especially as the description of the objects needed to generate an image can take up more memory than the image itself. He concludes:

Computer graphics is in the end just a set of technical tools for producing imagery whereas multimedia is a set of tools for using imagery.
(Booth, 1994; 14)

While some users may be deterred by the complexity of generating new graphics, others will want to take advantage of the flexibility and power of that they can offer. Powerful computers of the future will allow the use of 2d and 3d models that the user can manipulate and experiment with. It will be possible for virtual reality type environments to be embedded in multimedia allowing the user to look at a scene or object from any angle - and even interact with other users.

More sophisticated graphical production tools will provide multimedia authors with easier ways of creating 2d and 3d environments, pictures and animations to be used as another resource at the disposal of multimedia authors.

While course designers can try to anticipate the ways a student will want to work interactivity and learner freedom can better be provided using Computer Assisted Instruction (CAI). CAI has been used in training and education for nearly 30 years. The last 15 years has seen a steady growth in the availability and use of personal computers. These computers can offer to the learner features such as individualised pacing, branching, immediate feedback etc., but their ability to display high quality pictures, play video, or sound has, until recently, been at best poor.

Although there was some experimentation with computer controlled video tape, the time these systems required to find a particular sequence was high and therefore their useability low. The invention of the laser disk allowed much greater computer control over replaying the video. The video was stored on a disk making it possible for the player to go directly to a section of video. The time required to find a specific section using one of these systems was a few seconds at the most.

Computer control of a laser disc player allows the selection of a video sequence under program control. With the appropriate hardware the computer's output can be overlaid on top of the video image allowing computer text, diagrams, menus etc. to be on screen with the video.

Butcher (1987) notes that video provides a combination of pictures and sound that students find compelling but passive, and that the computing environment is highly responsive but less attractive. Computer controlled video discs bring the strengths of both together. This combination of video and computer is described as interactive video (IV) because of its ability to find and display a sequence based on the user's actions at the computer terminal. Hart sees this combination as possessing properties of human-human interaction:

interactive video clearly has potential for effectiveness, since it offers a combination of two powerful media and two distinct modes of learning. At the same time, its flexibility offers forms of interaction which has many of the virtues of personal face-to-face communication (Hart, 1987; p186)

IV presented a whole range of possibilities - the users were in control and their actions made a difference to the outcome. Instead of following a path set by the teacher the users can make

their own route through the material. Many early IV programs were used in training to try to simulate a real life situation where the video of the situation would branch according to which of a number of possible choices the trainee chose.

While being interactive, these systems still did not truly integrate the video into the learning environment. Instead analogue video was simply piped onto the screen along with often crude computer graphics. Often either users watched a video full screen or worked with a CAI activity - the two were not well integrated. This was really video with CAI rather than video *integrated with* CAI.

Clark (1987) argued that interactive video discs (IVD) would be the medium of the future since it has a much larger capacity than CD-ROM. High quality video images on IVD take up less space than they would on CD-ROM. Clark demonstrates that only two thirds of a laser disk is required to hold the entire Encyclopaedia Britannica, including all the pictures at video resolution. The increasing popularity of digital CD storage shows that the speed, ease of use and integration of the digital medium is preferred over the greater capacity of laser disc. For that reason interactive video discs were only a transitory technology as Chen (1990) observes while looking forward to digital video:

Video discs will compete with digital video for the next years then DVI or CD-I will supplant analog video. Digital video can offer the potential for significantly enhancing user control, learning environment, and expanding the views of interactivity" (p.15)

The digital storage medium of CD-ROM offers a way of storing the large amount of data required for video, on a small disc. This large digital capacity can store digital representations of text, video, sound, digitised pictures, program code, animation and graphics - in fact data representing just about anything. This large flexible storage method means that all this data is readily available to the computer and therefore the user. It is this integration of component media that forms the technological basis of multimedia.

Systems equipped with a CD-ROM drive and the power to play back video and sound are becoming increasingly common and affordable. Only a year ago such a system would have been out of the question in most parts of education, but is now found increasingly in many schools and homes.

Multimedia has almost progressed as far as it can with the integration of media. The near future will bring smaller, faster machines, higher quality displays and even greater storage capabilities. There is a push towards networking and communication though this just extends the scope of multimedia, rather than requiring any redefinition. It is in the understanding and use of these systems where we will see the most future development.

The technology has progressed so rapidly that multimedia now presents a wide range of possibilities for education. While many of these possibilities have been recognised there

still is little multimedia software that has been able to make effective use of them.

Education experts need to be thoughtful about developing the use of this technology in education so that the true potential of multimedia can be realised. To do this they also need to be not only aware of the capabilities of these new systems but to be aware of what learners require.

1.1.2. Recognition of the learner in education

It is not only the technology that has evolved during the creation of multimedia, educational thought about learning has been reassessed partly in the light of the new possibilities that multimedia has opened up. With interactive video in mind, Hart (1987) observes that it

may provide the opportunity for more genuine and spontaneous interaction between students and material. This would be very much in line with recent theoretical and practical developments in education (Hart, 1987; p 173)

It is the possibility of interaction between the learner and material that makes multimedia of particular interest to educators particularly given the recognition of the importance of the learners as individuals in education over the last three decades. Learners have different types of language, background, and tradition; each need to work at different paces and in different styles.

Romiszowski (1986) describes a detailed view of the historical evolution of individualised learning, which is summarised here. The move towards individualised learning really began in the early 60's with calls such as De Haan and Doll (1964) proposing programmes to make schooling more adaptable to the differences among students. This move gathered momentum as it became increasingly clear that students not only differed in intelligence but in creativity, different elements of intellect, competence, performance, physical ability, social behaviour. The recognition of these differences led to changes in the system of learning by rote or whole class instruction, by the introduction of more individualised tuition such as tutorials, and informal programmes of independent study.

Recognition of the need of different learners to work at different speeds, and from different perspectives led to the increase of programmed, and branching programmed, instruction courses. Computer based learning systems later enabled greater complexity in branching instruction and permitted 'drill and practice' and simulation programs.

This evolution has been a move away from the idea of learning being knowledge reception to being knowledge construction. Knowledge reception was, and often still is, the way that most education takes places. It assumes that once the gaps in the learners' understanding have been identified it is only a matter of filling these gaps by providing the student with the correct information. As Mayes (1994, p7) explains "[knowledge reception] entails a belief that

knowledge is something that can be passed largely intact, from teacher to student". This teaching by telling is not enough for learning since knowledge cannot simply be delivered to the student, but requires reconstruction by the student. Mayes describes this knowledge reception model as "so incomplete, and its emphasis so misleading, that it leads to a[n] ineffective instructional approach. This leads to a prediction of failure for much current educational technology" (Mayes, 1994; p8).

In contrast, knowledge construction (constructivism) demands that the learner processes the information and constructs an understanding of the concepts that fits in with their current knowledge, rather than trying to slot in someone else's knowledge. This type of learning, therefore, needs to be personal to the student since each student will need to consider different aspects of the information at different depths or in a different sequence. The challenge for multimedia is to supply the information in such a way that it supports and encourages this constructive learning process.

Romiszowski (1986; p.23) observes "the essential difference between teacher-based and media-based instruction is that the accent moves from the teacher teaching to the learner learning". This may be true to an extent but is the change in media enough to facilitate effective learning?

Multimedia has the potential to do this. Properly produced it can be interactive and adaptive: interactivity giving meaningful feedback on student actions, and adaptivity adjusting strategy and content representation to best fit with the student's way of working.

The technological development of multimedia has reached a point where its component media are fully integrated, and reasonably priced systems can be made available in education where needed. An important feature of these systems is their potential ability to satisfy the demand for individualised constructive education. For this to be possible research is required to investigate how learners might use them in their learning. This thesis focuses on the learning effectiveness of aspects of these systems.

1.1.3. Interest in video

This thesis takes a particular interest in video in multimedia. This interest is partly because the new technology has recently made it possible to integrate video into CAI. Video in multimedia is important since it is this ability to include video that makes multimedia different from other forms of computer based instruction. The possibility of including video in this way is new and its implications need examining.

Video itself is already a 'multimedia' medium in some respects, because it effectively combines sound and image as a relatively recent evolution from film. Multimedia is a new

medium, as film was in the early twentieth century, and given the similarity between the two, it is likely there will be parallels in its development. Since multimedia incorporates video, it is likely that video's construction, grammar and properties will play a large part in multimedia.

While research has been undertaken into the use of video in education, video in multimedia may be quite different. Video in multimedia maintains its textual richness, but it is no longer either a linear or a 'passive' medium. Multimedia creates the possibility of interactive user controlled ways of working that may mean the ways of using video are quite different.

1.2. Aims and approach

This thesis aims to discover more about the effective use of multimedia in education, particularly looking at the implications of video's integration into the medium from the point of view of its effectiveness for the learner.

This study is exploratory in nature since it is still early days for multimedia in education. The rapid development of the technology compared with the slower development of the understanding of this medium means that there is little knowledge about the medium that relates to its use rather than relating to the technology. There are three reasons for the increasing desire to see research that investigates how to design multimedia:

These systems are becoming more affordable and available in education. Teachers recognise that they can do more with these systems than just use them as a data base.

Authoring tools make the production of multimedia programs a possibility for educators themselves, but being a new medium they are unsure of what to do with it, and have no examples to learn from.

Programs on the market for education are often disappointing and do not live up to the claims or potential of multimedia. Both educators and developers are keen to know more about how the medium should work.

This study aims to address this need for research into how the medium operates.

The thesis takes a two edged approach. Firstly care must be taken to design systems to guide and support the way that the learners want to work rather than trying to make learners adapt their approaches to match the machines. For this reason the thesis looks at the learners using the systems to try to determine what users expect and want from multimedia. From this approach comes design considerations for how multimedia can support and encourage students in their learning.

This thesis also examines multimedia by looking at the existing use of media - particularly video, for the reasons discussed earlier. By searching for and being aware of the properties of

the medium of multimedia it is hoped that it will be possible to extend understanding about learner use of the medium and look to how it may develop in the future.

Given the arguments developed in the previous sections about learner freedom and video the overall aim of the thesis is to investigate how the design of video in multimedia relates to learning effectiveness

With this in mind the following section details the structure of the remaining chapters in the thesis.

1.3. The Structure of the Thesis

The next chapter is a literature survey, designed to anchor the research in the current knowledge of the component media, and to look at some of the existing research relating to video, multimedia and education.

The chapter begins by looking at each of the component media in turn, considering the strengths and weaknesses of each one, and looking at their role in multimedia. Next the chapter looks more specifically at multimedia, from existing work in the area. Its pedagogic properties of interaction and learner control are examined.

Considering that multimedia will have much in common with the existing use of video the chapter then goes on to look at the structuring of multimedia from the perspective of video. The grammar, narrative and argument structure of video and film and their possible relationship to multimedia are explored through current literature in order that this may be extended in the discussion in later chapters.

Chapter 2 raises a number of questions from the current literature on the component media. The initial empirical work carried out was a study to try to determine what the issues are when multimedia is used in a real environment with real users. The preliminary study, described in Chapter 3 takes the form of a qualitative evaluation of Price Waterhouse's computer risk auditing training video disc - 'TerminalRISK'. This detailed evaluation of a well developed interactive video being used in a real training situation provided a basis for identifying some of the key issues in multimedia usage.

Having identified in the previous chapter some of the key issues in the design of multimedia, especially those relating to the role of video to carry a narrative, these are put to the test in a specially designed empirical study. Chapter 4 describes the first phase which uses three educational texts to teach exactly the same material about the use of scientific models. Two of these are specially designed multimedia programs and the other is a video version. One multimedia program is similar in the amount of freedom to navigate it provides to the video program but does provide the user with some control over pacing. The other multimedia

program provides greater user control and provides feedback on the user's progress. Thus the three versions offer different degrees of learner control over the 'narrative' line in the video.

The evaluation focuses on how the users work with the three different systems, looks at their problems and tries to relate these to particular design factors.

This chapter also looks at some of the issues arising from the conversion of an existing linear video taped programme for use in multimedia. The conversion process itself turns out to reveal much about the nature of video in multimedia.

The first part of the study in Chapter 4 revealed parts of program design that were confusing or did not fully exploit the properties of multimedia, in particular, its potential for interactivity. Chapter 5 covers the design and testing of a new multimedia program that takes the findings of the first phase a step further, and through restructuring the material from the first phase fully takes advantage of multimedia's capabilities. The properties of interactivity and learner control are investigated as ways of improving the learning effectiveness of the material.

Issues raised in the previous chapters including the use of narrative, structuring of the content, and production of video, are taken up and used in a discussion on the possible form of a grammar of multimedia. The idea of a grammar for multimedia, much like a grammar of film or television, may be a good way of understanding how the medium works and how an educator can begin to construct an argument using it. For this reason Chapter 6 begins by looking at what constitutes a grammar of a medium and then looks at the grammar of film and video. Using the grammar of video as a reference, the chapter goes on to look in more detail at what some of the elements of a grammar of multimedia might be, and considers the relevance they have for the use of multimedia in education.

The final chapter pulls together the conclusions from the previous chapters to draw out the implications for instructional design and for multimedia design and their relation to learning effectiveness.

The chapter also reviews the methodology, looking at what worked successfully, what did not, and what can be learnt from this for further experiments.

Chapter 2: Literature Survey

2.1. Introduction

There is little research in the specific area of video in educational multimedia that is directly relevant to this study. Part of the reason for this is that the technology involved is new - the first working example of digital video being played from CD-ROM was in 1987, but it is only now that the technology has become a realistic option for educators. There is, however, a sizeable amount of related work from various academic disciplines that covers the component media in multimedia. Research into CAL systems and Hypertext is particularly relevant.

Due to the nature of multimedia it is necessary to look into a number of different research areas from CAL to television theory. The first part of this chapter looks in turn at each of the component media that make up multimedia, examining their strengths and weaknesses. The chapter then goes on to look at issues relating to learning from media. Next, some of the pedagogic aspects of multimedia such as user control, freedom and interaction are examined before turning to the structure of educational media, paying particular attention to educational film and video construction. Finally this chapter draws together the preceding sections and examines the design of educational multimedia.

2.2. From Multiple Media to Multimedia

2.2.1. Multiple Media

... no single medium is likely to have properties that make it best for all purposes. There is, so far as we know, no special magic in any particular medium. Gagné (1971)

The term multimedia today is used to describe a wholly computerised system that encompasses many of the elements all under computer control. The term was originally used to describe a teaching package that contained a range of different media, such as printed text, video tape, slides and in some instances computerised programs this combination is now often referred to as *multiple media* in order to differentiate it from computerised *multimedia*. Multiple media packages are still common, especially in distance or open learning. An understanding of their use and design is important during the investigation of multimedia.

In this section we consider the lessons that can be learned from the earlier forms of multimedia and discuss each of the various component media looking at their particular strengths and weaknesses and uses in education.

2.2.2. The Role Of Print In Education

The traditional way of presenting and recording information, be it courseware or fiction, is print. This section looks at the use of printed material in education, its strengths and weaknesses and its role in multimedia.

'Print' technically speaking is anything produced by a printing press - including diagrams, charts and pictures. It is normal to suppose that this is paper based, but if a wider definition of print is taken to mean any textual information then text on the computer screen can be considered also.

Print based material is a symbolic representation of language, though the language of print is different in a number of ways than spoken language. Some of the strengths and weaknesses of print are related to similar strengths and weaknesses in language. Carroll (1974) addresses some of these complex issues.

Logistically, print has many advantages over other educational media: "it is the easiest medium to design (single author), to produce (established publishing mechanisms), to deliver (book shops and libraries), to handle (light and portable), to use (random access, contents, indexes)" Laurillard (1993: 134). Given the current context of multimedia and the new possibilities of electronic publishing, the logistical considerations have changed. However, to establish print's new role in multimedia it is necessary to consider its pedagogical characteristics.

The ability of the student to be able to control the focus of the topic by re-reading, skipping, browsing and selecting sections from the index or contents is noted by Laurillard (1993). The student in this way can determine the pace and depth at which learning takes place.

This controllability also allows the author of print, such as an educator, to produce a concise textual description of a concept. Writers have time to consider their words and the structure of their sentences in more detail than they could in speech. Spoken language is necessarily simpler since the listener is not able to control the flow, or re-read sections. Authors of the printed word relinquish control over its interpretation once it has been published. For this reason care must be taken during writing since the reader has discretion over reconstructing the author's original argument (Säljö, 1984). This control over the written word compensates for the lack of cues in spoken language such as pitch, emphasis and rhythm that can help guide the reader towards a particular interpretation. For educational material an agreed interpretation is normally desirable. This extra detail in text means that, while they cannot be avoided, other interpretations can be minimised. For an extreme example see legal literature (Carroll, 1974).

The weakness of print lies in the fact that it is not interactive, adaptive or reflective, but these problems can be overcome. As Laurillard (1993) points out, the British Open University has achieved a form of interaction and adaptivity with techniques such as in-text questions and activities and the provision of supplementary texts for students who need to spend more time on an aspect of the work. The university chose to use these effective techniques because of the necessity of using print for much of its distance learning. Perhaps if a medium that provided interaction and adaptivity was as logistically viable as print this would have been used instead.

Salomon (1979) finds that readers of print need to put more effort into the processing of the material they read than they would if they watched the same material on video, and as a consequence they make more mental elaborations and inferences. (See the section on video for a fuller discussion of this study.)

Print is symbolic in nature and so can only present a symbolic description of the world to the learner. Video, on the other hand, can go further towards providing a vicarious experience. For presenting complex concepts and relationships, print's static nature is good. While not supporting functions such as interactivity, adaptivity and reflection directly (though it can be designed to compensate for this) it is able to provide a detailed argument over which the learner has fair control, and is a medium with many logistical advantages.

The presentation of text on the computer screen has disadvantages. Users find reading large amounts of text from screen tiring and are unable to have the same tactile experience of the text as they do when holding the paper in their hands. The other problem associated with on screen text, particularly in hypertext, is that the author of the text writes 'nuggets of knowledge', each node being self contained. This is an acknowledgement that the learner will select a path through the material, so the author, instead of stringing an argument together, provides a series of 'screen-fulls' that are not linked in the same way as conventional text (Whalley,1990).

2.2.3. The Role Of Audio Visual Material

The use and power of audio-visual material has not been fully recognised in education. In business and industry it has been better recognised and used more widely, from boardroom presentations to rolling product demonstrations and workforce training. These types of presentations are often as effective as video or film and share the same type of properties, but are much less expensive to design and produce. Often photographic slides are synchronised to cassette tape either by computer or by a special track on the audio cassette. The use of two or more slide projectors enables smooth transitions between slides and some quite complex effects. This kind of set up is particularly suitable for large presentations but allows little

possibility for user control during playback - such systems may be paused to allow discussion, but it is very difficult to skip forward or backward in the sequence.

The more common use of audio-visual material in education is to use an audio cassette in combination with printed material. The audio cassette has much greater controllability. It is possible to skip forward and backward, pause and repeat sections. It is even possible to use the counter to index and find specific sections (though there are problems with this since the counter does not give an absolute position and so needs resetting at the beginning of the cassette each time). In addition there are many different counter systems on playback machines making comparison between machines almost impossible.

The printed material accompanying an audio narration can consist not only of text but of diagrams, graphs and pictures. The audio provides an easily interpreted narration that, since it leaves the visual channel free, enables the learner to look at a diagram as the voice tells them what they are seeing or what to look for. The use of narration here has parallels with Salomon's (1979,1984) and Cennamo's (1993) descriptions of the ease with which the visual input channel of video is decoded and interpreted, since this is a 'real life' process that the brain can accomplish easily (see the section on 'television', for a full discussion of this). A further benefit is that spoken language on tape does not lose semantic information carried by the reader's voice, for example emphasis to signify that a particular point is important.

The visual part of audio-visual does not need to be printed material. Laurillard (1993) uses the example of a geology course that includes a rock sample, where the audio talks the student through the look and feel of the sample. The audio may also talk the students through an action, such as cutting a piece of rock, or working with a specific software package. If the results of the actions at each stage are known then the commentary can describe the process. It is for this reason - that something changes in the 'system' as a consequence of the student's action - that Laurillard (1993) includes audio-visual amongst interactive media.

Multimedia systems have the capability of including audio as another data type to integrate into a educational package. The use of on screen pictures and diagrams with audio from CD-ROM is equivalent to the combination of tape and slide that has been successful in business, where as the new medium offers a degree of flexibility to this type of system that was not possible before.

2.2.4. The Role Of Video and Television In Education

This thesis considers the use of video in educational interactive multimedia. Though I will refer to work written about broadcast television I will do so only to draw out points relating to

the use of video and avoid attributes that only relate to television. These include aspects such as television's immediacy and lack of user control.

At a purely technical level video captures moving low resolution colour images and sound that may be replayed at the user's demand. Modern video cameras can be taken almost anywhere; they provide recorded visual footage of almost anything; they can be attached to microscopes or telescopes. In fact anything that can be seen by some method can be video recorded. Video can go even further than this and make it possible to see things that otherwise would not be visible. Time lapse photography can be played back on video, showing visually movement that otherwise would be too slow to see. Image intensifying video cameras are used to see in light levels far lower than the human eye can operate in. High speed recording enables us to see and analyse events that would otherwise happen far too quickly to be seen. All of these abilities have implications for education, since the educator can use this technology to show the student moving video pictures of almost anything.

Video as opposed to television offers the possibility of some control. Viewers are able to watch the video when they choose and have the ability to review the whole video, or specific sections, as many times as they desire. The limitation with tape based video is the time taken to wind the tape to the correct point, which at best is time consuming, but often requires stopping and playing the tape to see where in the programme the tape is since the tape counter is only relative to the tape position rather than giving an absolute reading (unless the video player and tape is of sufficient quality to be equipped with a time code track).

Video tape players additionally give the users the potential to visually play the tape at various speeds either forwards or backwards, repeat a sequence or freeze the motion in order to examine just one frame at a time. This degree of control can either be used by the teacher in presentations or by the student to see for themselves specific material and to examine the motion or detail of a still frame.

The above are technical possibilities for whichever types of material can be recorded, but the actual usefulness of video depends on selection of appropriate material, the choice of presentation format and the appropriate use of televisual codes for argument construction. The appropriateness of the use of video as part of an educational course depends of the specific strengths of video. Bates (1979) lists eighteen functions that video can be used for in education. Bates does not attempt further analysis of the items he lists, since the list is designed to be a reference in creating successful audio visual budget bids. Elements on his list can be categorised as falling somewhere between the technical and constructed properties of video. The technical aspects of video are items such as the use of "animated, slow-motion, or

speeded-up film or video-tape to demonstrate changes over time." The constructed aspects are those that do not rely purely on video's technical nature, but instead on the use of video's grammar. Bates' list includes functions such as the ability to "change student attitudes [...] by presenting material in a novel manner, or from an unfamiliar viewpoint", to "demonstrate decision-making processes" and to "condense or synthesise into a coherent whole a wide range of information which would require considerable length in print" (Bates, 1979: 5).

Bates' list was drawn up by considering programmes that have been produced at the Open University. Koumi (1991) using the same material, considers the educational roles that video can play and lists three such roles:

motivational. Video can have the ability to motivate the learner. It can be used to construct a narrative in video, to present a story using grammatical and televisual devices to create tension, sympathy and suspense. Video can be motivating when the students get to see real life examples of their work, being another way of connecting theory to real world applications. The well practised rhetorical production techniques of video for entertainment and advertising can also be used in video. If some enthusiasm or fascination for the subject-matter is created then students will be better motivated towards study.

cognitive. As well as being motivated, students can learn from video too. A narrative structure can be built that takes the student from point to point in an argument describing and illustrating each point with all sorts of visual and audible resources. The complex grammar can be used not only to show the learner various scenes, but to guide the learner towards a preferred interpretation.

experiential. Video is able to fulfil experiential objectives "taking the viewer on a (vicarious) field trip to an inaccessible location" (Koumi, 1991: 134). Using video it is possible to bring together electronic representations of key items, places, action sequences, people, data representations etc. Selected material taken from different times and places can be shown to a student.

An important attribute of video for education is identified by Laurillard (1993). She suggests "The power of television in the difficult trick of conveying a particular viewpoint on the world is frequently underestimated." and goes on to say "Television... is peculiarly able to convey a way of experiencing the world, because it provides a vicarious experience through dynamic sound and vision". Laurillard (1993:142) goes on to argue that video has a rhetorical power and that since "academic knowledge is essentially rhetoric" educators should be at liberty to exploit this rhetorical power of video.

Video, it would appear from the discussion above, has the ability to change attitudes, motivate, convey viewpoints and experience, and promote meanings and interests. But how

can video provide a substitute for direct experience of the world, or allow a student to understand the viewpoint of the teacher?

Fiske states "Television does not "cause" identifiable effects in individuals; it does, however, work ideologically to promote and prefer certain meanings of the world, to circulate some meanings rather than others, and to serve some social interests better than others." (Fiske, 1987 p.20)

A look at the way that television represents and encodes reality may help to identify where its rhetorical power lies. Video does not give a veridical window onto the world by which the viewer can experience a version of what they would have experienced had they actually been there. Through a number of devices and the nature of the medium, the image on the video screen is not a true reflection of the world and reality. Fiske (1987:4-6) identifies three levels of codes that 'reality' passes through in order that it can be "(a) transmittable technologically and (b) an appropriate cultural text for its audiences".

Firstly, existing social codes such as appearance, behaviour, speech and gesture that operate on the level of 'reality' are encoded electronically. Already these social codes have been encoded by our perception since the way in which we make sense of reality is by the codes of culture. But in video these elements are controlled and coded to varying extents by the video's producers. The 'reality' is encoded at a second level by representation. Encoding at this level is twofold, first the technical coding effect of camera, lighting, editing, music and sound, and then again with the conventional representational codes of video grammar such as narrative, conflict, casting, setting and action. The video's production is then encoded a third time at an ideological level by its makers. In making the video the ideological perspective of the programme makers is included, as Fiske (1987) points out in the context of popular American TV "If we adopt the same ideological practice in the decoding as the encoding we are drawn into the position of a white, male, middle-class American (or westerner) of conventional morality." (p. 11) It is during the reading of video or television that the mix of social, televisual and ideological codes are combined to make a coherent, unified sense.

The encoding levels of 'reality' and ideology are inescapable parts of any media representation, though perhaps especially so in a 'rich' medium such as video. The techniques and devices that are used at the representational coding level differ between media. Working at this level Salomon (1979) describes the use of these devices to manipulate experience as 'supplantation'. Devices such as the zoom in video can save the viewer from mental elaborations. Salomon uses the example of the zoom from a wide shot into a specific area as overtly supplanting the process of relating that area to the whole. What is of particular interest to educators is the possibility of this supplantation modelling mental elaborations that the user cannot perform. Laurillard (1993) uses the example of an educator

who wishes to convey a complex theoretical idea, such as a Riemann surface. The use of devices that supplant mental elaborations will help the learner. In the case of Riemann surface Laurillard describes an example that uses trick photography to make a man seem to get smaller as he walks along a radius crossing concentric circles which gradually get closer together. This visual representation of the surface can bring the learner to a position of understanding at which they could not arrive from words alone.

Salomon goes on to consider the possibility of devices (complex coded messages) that not only simulate mental elaborations but in fact 'short-circuit' processes of elaboration, providing the learner with the ready-made results of elaboration. While not dismissing this as a possibility, he suggests that if an internal activity is short circuited it may prevent mental elaboration altogether. Mental elaboration is the process by which new knowledge is linked and stored in the learner's mind. To completely short-circuit the process would be to go to far.

If missing or more effortful mental elaboration skills can be short-circuited by activating a different set of more general or better practised mental elaborations associated with the televisual device being used then perhaps this short-circuiting is where some of video's rhetorical power lies, and still may be useful to educators. If the televisual device can allow the user to see a particular point of view, even if some of the mental elaborations involved in getting them there have been short-circuited, then maybe this new position can still be used to activate or build other mental skills.

Though Salomon (1979) offers some experimental evidence to support his theories, the work falls into a large area of how learners interpret and code televisual grammar which is hard to investigate, and consequently there is little research in this area.

Salomon (1979) cites Meringoff's (1978) study that compares childrens' understanding of a televised story with a story read aloud. Children that had listened to the verbal story generated more inferences and connected the story to more of their own general knowledge than the children who had seen the video version. Salomon argues that video is more congruent with the childrens' internal representation ('symbol system'). Simple video requires the same sort of processing skills that are needed to interpret the everyday world around us and consequently is easier to record. On the other hand, the processing that is necessary to decode and interpret speech is much more complex and requires the learner to draw upon their own memories and fantasies. The difference between the two indicates that video requires less elaboration since it is more directly meaningful - "The pictorial system of television *allows* (but does not require) shallower processing than a written story or a verbally told one." (Salomon 1979:p223).

This implies to the educator, who wants to ground the viewer in an argument quickly, that the easier reading of television may be useful. However, if the educator requires the student

to indulge in greater processing and elaboration, then the material needs to be designed in order to direct the student to do so.

It is not uncommon for television *viewers* to be considered passive rather than active *readers* (hence the 'couch potatoes' slur). This may be true to some extent with popular entertainment television (though Fiske (1987) gives evidence against this), is it the same for educational television and video?

When discussing educational television, Plowman says "Children (and some adults) often believe that because it is 'on television' it must be real. The monitor gives the content an authority which should be more open to question although rarely invites this." Plowman (1988). In educational television viewers are given little reason to doubt what is said and accept it in good faith so that they may continue to follow the argument laid out before them. The television or video program moves steadily on, and gives no time for contemplation and construction of contrary arguments, especially where the viewer does not have much knowledge or any previously defined beliefs about the topic. This may be of use if the video is to be motivational, or is to bring a learner to a superficial understanding of a point in order to build from there, but it is less useful if it is necessary that the learner has a good retention of the argument (Thorson, Reeves & Schleuder, 1985). If good retention of details is needed then it is important to allow the students time after watching the video to collect their thoughts and to review the argument. "Programs that provide pauses following complex elements ... may provide time for perceptual processing and for viewers to make sense of the message relative to their existing schemata before additional critical information is presented" Cennamo (1993)

Salomon (1984) investigates the mental effort perceived and actually expended by learners using video, in a comparison between print and television. The study was carried out with sixth graders from a middle class school in the States. Two groups were randomly assigned to work with either a video or a booklet. The booklet was carefully written to have comparable content, humour and explicitness to the video. A week earlier the students had completed a questionnaire designed to determine their perceptions of the media (e.g. low or high realism) and their perceived self-efficacy (how easy / hard is it to learn from a book / video). After they had used the material they completed another questionnaire to assess their amount of invested mental effort (asking questions about how hard they tried to understand the film / book) and to measure their achievement (both inference making and factual recognition). The study revealed that the amount of invested mental effort of the student related to the learners' perception of the material and their reading skills. Video was perceived to be "lifelike" and therefore easy, and the students' perceived self-efficacy was high. This may have led students to approach the material with less effort than they should have and consequently to put less effort into processing and elaborating. This was confirmed as the

achievement results for inference making were significantly higher for print than video. Salomon's study set no clear objectives for the learning. This is perhaps where some of the problem lies.

Cennamo (1993) argues that the perceived effort of learning from video is dependent on the characteristics of the learner, of their learning experience (Bordeaux and Lange, 1991) and their cultural experiences (Beentjes, 1989, Salomon, 1983). Cennamo (1993) cites work by Kunkel and Kovaric (1983), Beentjes (1989) and Salomon (1983) who show that the perceived effort is further affected by the content of the task. Unsurprisingly some topics are perceived as being more difficult than others.

"The amount of effort invested in processing a video-based lesson seems to be influenced by the symbol systems employed by the medium, the complexity of the materials, the structure of the program, the perceived purpose of the task, and individual characteristics of the learners." Cennamo (1993).

As well as the cognitive issues involved in learning from television, Koumi (1991) talks about the use of television and video to motivate a student. "If the teachers can create an enduring fascination for the subject-matter, the job's almost over: the more the students love the subject, the less help they will need in their studies". Duby (1991), while looking at what educational television and video might learn from existing television formats, suggests ways in which the medium can motivate learners. Duby looks at television formats such as 'Music Video', 'Advertisements', 'Game Shows' and 'Documentary' to see how it effectively motivates and keeps audiences with these formats, and how elements from these formats might be included in educational television without sacrificing the educational principles.

Video is not an interactive medium so is unable to provide feedback, remediation, and individualised pacing nor can it adapt content to individual needs (Chen, 1990).

Video would appear at first examination to have great potential. It is an informationally rich medium that through a complex grammar is able to construct detailed rhetorical narratives, provide experience, motivate and entertain. It can even supplant cognitive processes. It is easy to see how some early proponents of educational film had such great hopes of the medium. Video of course has shortcomings. It is a continuously running medium that does not easily allow for reflection, though some Open University programmes prepared for use on video rather than television do instruct the student to stop the video to reflect on the section that they have seen though often these cues are ignored (Durbidge, 1982). By providing a complete non-interactive presentation of sound, vision and narrative that is easily interpreted, it does not readily invite mental elaboration by viewers who, while they may enjoy following it, do not *need* to apply themselves to it. It is a linear medium which makes it difficult to access, control and search, and it is not interactive or adaptive.

2.2.5. The Role of Computer Assisted Learning in Education

Another aspect of multimedia is the computer system that integrates and co-ordinates the other media and provides an interactive interface to them. This section looks at computer assisted learning in education. It covers the areas of free access databases, hypertext, simulation and tutoring programs.

The merit in transferring an undergraduate text book from printed format to a computerised format was investigated by Riding and Chambers (1993). Their study compared the paper based version of a text-book to a version stored on CD-ROM. The CD-ROM version consisted of a hierarchical structure so that the user could click on the chapter heading first, then sub headings within the chapter and then read the text of that section. It was also possible to access the material through a similar hierarchical structure based around an index of subjects. The 40 undergraduate subjects who were due to study the material as part of their course were randomly allocated between the two versions. The subjects working with the textbook were reminded to use the book in a flexible manner and of the value of contents and index sections. Both groups were given the same task of answering a number of questions that were designed to test factual, interpretative, comparative and deductive understanding and both spent the same amount of time working with the material. A statistical comparison between the two versions, revealed that the students that worked with the CD-ROM were superior in all question types apart from comparative questions (for which the lack of illustrations on the CD-ROM, that were present in the original book, could be responsible). The success of this conversion perhaps lay in giving the students greater access to the material. The text whether printed on paper or on a computer screen remained unchanged in both content and structure.

Hypertext takes the database search on text a step further. Where a search turns up sections with matching text, the creator of hypertext can establish links between related ideas or concepts. Accessing the information in this manner takes the reader on a non linear route through the material of their own choosing and not in the way the original author of the text could anticipate. This 'browsing', it is argued, facilitates "learning incidentally by discovery and exploration" Jacobs (1992).

Jonassen (1990) goes much further than this almost haphazard way of learning from hypertext asserting that hypertext can mimic the associative networks of the human memory and that a semantic hypertext network developed by an expert or teacher in a subject area will enable the user's mental knowledge structure to increasingly resemble the knowledge structures of their teachers.

Such claims of learning in this way have not been experimentally validated yet. In fact there is some scepticism about their use. Whalley (1990) describes the notion that "the

arbitrary 'webs' of facts in hypertext systems have much semantic significance" as mistaken. He argues that the web structures of hypertext are not of the same order of complexity as human semantic knowledge structures, and doubts that simple hypertext can solve the conceptual problems involved in representing complex semantic knowledge structures or that "the detailed hypertext web created by one individual has very little meaning for anyone else." (Ibid.: p63).

Hypertext systems do allow the user to be in control of their path and pace through the information but as Mayes, Kibby & Anderson (1990) observe "One must ask whether, even where the user is in control, simply navigating around fixed links will provide learning" (Ibid.: p123)

Hypertext and database oriented computer aided instruction may provide user control but they lack interaction - their activities are little more than page turning and browsing (Hammond 1993; Laurillard 1993). Interaction requires something within the system to change as a response to the user's actions. Simulation and intelligent tutoring systems manage this by providing feedback that reflects a change in their state due to a student action.

A further use of computer technology in education is 'simulation'. "A computer-based simulation is a program that embodies some model of an aspect of the world, allows the user to make inputs to the model, runs the model, and displays the results" Laurillard (1993). The simulation may model anything from a mathematical formula, the economy or a nuclear power plant (Moyse,1991). Simulations are particularly useful for representing complex relations where it is not easy to express the relationship between the inputs and results clearly. The simulation itself does not determine goals for the learner, though these may be implied (e.g. generate power output to meet demand). It is the users who decide the topic focus in determining which variables they set. The system does not judge the correctness of the user's decisions on input, but reflects the consequences of the input in its output. A series of poor decisions in the power-plant simulation may lead to the plant shutting down.

A simulation may model only certain aspects of a system, or show the system from different viewpoints. Moyse (1991) compares two simulations of a power plant - one a structural model of the plant describing the flow of energy through the system, the other a 'task-action mapping'. His study shows that the two ways of modelling the same system allow the learners to perceive the internal workings of the system differently.

In education, the same simulation may be used to follow different properties of the same system - the teacher perhaps setting the goal (e.g. "find the parameters where the system is stable" or "what happens if you can't change the setting of steam-value 'A'- how do you compensate for the loss of pressure?"). Or this setting of goals may be done by the learners themselves.

Unlike database and hypertext based computer aided instruction, computer simulation is interactive since the learner's actions change something in the system that determines the feedback.

A further form of computer assisted learning is the tutorial program and tutoring system. The tutorial program is different from the other examples discussed so far since it embodies an explicit teaching strategy. Laurillard (1993) lays out the basic design process for a tutorial program as follows:

- specify a learning objective,
- offer a brief introduction to the topic,
- set a task according to a strategy for achieving that objective,
- interpret the student's performance on the task,
- use this to select the appropriate feedback,
- use the student's performance so far to select the next task.

The program should be defined to give students extrinsic feedback on their actions and to adapt the tasks relative to the student's actions and the overall goal. Unfortunately it is rare to find tutorial programs that embody all these.

It has been suggested (Hammond,1993), that hypertext is perhaps useful as one of a set of tools, with its own strengths, from the educational technologist's toolbox to be used alongside other techniques. Riding and Chambers' (1992) work shows that given the specific task of answering the given questions the free access database worked well. This must be due, in part, to the system's ability to store, retrieve and manipulate information quickly and so frees the learner from some of the drudgery. Simulations can have great flexibility in allowing students to understand complex systems, but can not offer a specific teaching agenda as a tutorial program can.

While there are many possibilities for the use of CAI in education, it is limited by its heavy reliance upon abstract and verbal teaching and misses the richness of the dynamic visual material of video (Chen, 1990). The technology of video disks allowed the controllability and interactivity of CAI to be linked to a quick access video system in the form of interactive video.

2.2.6. The Current Use of Video in IV

The early '80's saw the development of interactive video disks where the analogue video signal was written onto the surface of a disc allowing quick access to any part of the video

stored on the disk. Computer control was developed to link this ability with computer aided instruction. Computer graphics and captions were later overlaid (genlocked) onto the image for better integration. More recently new hardware (such as the Videologic boards) was developed to include the video image on the computer's screen either as a full screen image or a 'window' in the computer's display. In interactive video, the inherent limitations of CAI and instructional video have been overcome - the interactive capabilities of the computer and the unique properties of video presentation have been brought together (Chen, 1990). In describing the potential of interactive video, Duke (1981) says "[interactive video] combines the rich and varietal sensory experiences offered by television with the detailed control characteristics of computer-based learning".

Floyd and Floyd (1982) define interactive video as "...any video program in which the sequence and selection of messages is to be determined by the user's responses to the material". The first training and educational video disks did little more than this. They involved users watching a video sequence (e.g. of an angry customer) and at key points making decisions which affected the selection of the next sequence.

Plowman (1988) suggests two common ways in which interactive video disks have been used in the curriculum. The first is teacher led where the teacher takes advantage of the ability to control and sequence good quality pictures and video clips. This teacher is already likely to have enthusiasm and knowledge of computers, and to use IV as a resource for hundreds of still and moving images and to adapt and modify existing programs for their own purposes (Duke, 1981). Teachers use the medium as a database to supplement teaching and retain control of the multimedia and instruction of the students. The second way is student led: IV disks are used as a resource base for audio and visual material which is accessed by the students as required.

As discussed later, there is a debate over whether this type of use can be truly described as 'interactive' since the student is simply browsing the material: the system is not giving feedback on the student's actions. (Plowman, 1988; Laurillard, 1993).

A particular strength of interactive video is the way in which it draws on the video's ability to show a film representation of 'real life' and to involve the viewer in a fictional account of events, via the computerised element of user determination over the course of events. An example of this in action is the simulation interactive video program 'Nightcall' produced by ICI Pharmaceuticals. This disk aims to allow general practitioners to become more confident in their management of patients with serious heart conditions. The simulation puts them in the position of being called out to a patient suffering a heart attack at home. All the consequences of the doctor's decisions on managing the situation are simulated, and are also reflected in the simulation of blood pressure and ECG trace of the patient, (Bayard-White,

1987). The display of 'real life' ECG traces that respond to the doctor's actions in a simulated emergency environment provides a form of intrinsic feedback on the student's actions.

Interactive video can be seen as a "blend of audio, visual and textual databases together with computing technologies" (Bayard-White, 1987). This more appropriately describes the level of its use today, such as that found in the study of PriceWaterhouse's 'TerminalRISK' program in Chapter 3. Such systems go far beyond the original definitions of interactive video, and have more in common with what is aimed for in multimedia - the seamless integration of text, graphics, audio, animation and video - multimedia.

The continuing advance in computer technology has brought us desk-top computers with powerful processors, large memories and vast data retrieval capabilities. Some practical limits have been reached with high resolution 24bit monitors being able to display more colours and detail than the human eye can distinguish, and 16bit sound producing sound of life-like clarity. MPEG video compression can play back a full screen 24 bit video image at a full 30 frames a second. This means that many forms of existing media have an equivalent in the digital domain. "Computer data will consist dominantly of fully integrated digital media - sound, video, graphics, animation, speech and text" Heppell (1993).

Jacobs (1992) sees multimedia as being (in theory) the "seamless integration under computer control of any text, sound, still and animated images, and motion video". It is then the computer control element that brings together the individual media to make multimedia.

CAI forms the heart of multimedia systems. The types of CAI programs discussed earlier (database, hypertext tutorial, simulation, ITS) all form frameworks for the possible integration of other media. Indeed types of CAI and multimedia systems may not need to fall into any one of those categories, or may draw from any of them as the subject to be taught dictates. It is because of this that the definition of multimedia becomes unclear. What is clear is that the constituent media (print, video, audio-visual, CAI) bring together the strengths of each medium with the capabilities of user control, large information storage, interactivity and adaptivity. The resulting multimedia has great potential for education.

2.3. Pedagogic Features of Multimedia

The previous section highlighted several key features of component media that are important for learning. This section considers how they affect the educational potential of multimedia.

2.3.1. The Role of Control in Learning

The necessity of allowing students greater control over their learning has been realised for sometime. Gagné (1971) argued that "The site of learning is the individual" and that "For this fundamental and unarguable reason, learning is individual". It seems logical to follow Gagné's argument with one Laurillard makes:

There is no well-established reason to suppose that a program designer, whether teacher, researcher, or programmer, knows better than the student how they should learn. Therefore when we are designing materials for a media that is capable of providing an unusual degree of individualisation via student control, it seems perverse not to take advantage of it. (Laurillard 1987, 4)

In addition to this Taylor & Laurillard (1994) suggest the control over learning is important in the students' development: since it:

helps to cultivate a sense of ownership, and foster a mature, scholarly and reflective approach to learning which will be valuable throughout life. (Taylor & Laurillard, 1994; 11)

While increased learner control has great potential there are some pitfalls too (Taylor & Laurillard, 1994). Students who are in experienced in a topic and / or directing their own learning find difficulty:

- in knowing how to ask the right questions and how to recognise appropriate answers
- in specifying goals
- realising the overall aims of the study
- evaluating their progress
- maintaining motivation.

Such problems may mean that the student becomes disoriented and loses interest or enthusiasm for the topic.

Multimedia provides much greater opportunities for learner control than have been possible with earlier media. The student not only has control over the depth, order and selection of material but being interactive it allows an extra dimension in user control - there can actually be a discourse between the learner and the interactive system. How does this new ability of the media work and how can it be used advantageously?

In defining learner control, Barker (1990) identifies the following elements that are under the user's command: what is learned, the pace of learning, the direction learning should take, and the styles and strategies of learning that are to be adopted.

Laurillard (1987) makes a more detailed examination of user control of learning. In a conventional classroom learning situation, the teacher has a constructed description of the world and aims to transmit this knowledge to the student. Laurillard contrasts this didactic model with a communicative model where knowledge is negotiated between teacher and pupil. The teacher's aim in this model is to facilitate the student's development of their own perspective on the subject. Students as a result also have more responsibility for the acquired knowledge and their learning. This approach also gives greater credence to the student's view of the world. In addressing the question 'can educational media operate in this communicative mode?' Laurillard considers three aspects of control :

- (a) learning strategy; can the student make decisions about the sequencing of the content and learning activities?
- (b) manipulation of learning content; the way a student experiences the domain being learned.
- (c) description of content; can the student construct their own perspective on the subject?

The extent to which each degree of freedom may be included in an interactive multimedia program will vary with the topic area being taught, but in general the more control that learners have over the program, the more control they have over their learning strategy.

Hypertext allows a large amount of user control, but no interaction. The learner is left to explore the material as they please. Plowman (1988) suggests that the students' freedom in governing their own learning may help their motivation; "Active learning has been developed in response to cognitive, as opposed to behaviourist, theories of learning and suggests that children learn most efficiently, and feel most motivated to learn, when they do so through experience and their own discoveries.". Hypertext does offer a high degree of learner control though it does not help to set a learning objective. As Jonassen & Wang (1993) observe "It has become increasingly obvious that learning from hypertext must rely on externally imposed or mediated learning tasks -- that merely browsing through a knowledge base does not engender deep enough processing to result in a meaningful learning". They go on to suggest that the reason for this is that hypertext is not engaging enough to result in more meaningful learning. This could suggest that, despite the level of learner freedom available in hypertext, without the element of a specific goal and interaction, the student will find it harder to attend to the learning task.

User control allows students to work according to their own strategies, but giving the user complete control, as in hypertext, leaves the learner floundering with little direction and motivation. Some mediated solution is perhaps best, where learners are given control, but are still in a didactic environment where they can access guidance and interactive exercises.

2.3.2. Resource Based Free Exploration vs. Didactic Instruction

The quick random retrieval of material and large data storage offered by computer controlled media has been exploited by the relatively new free exploration or 'browsing' modes of learning as used in hypertext, database, and more recently in multimedia contexts.

Depending on the system, a user working through a hypertext database, may browse, annotate and link information either as text, graphics, video or sound.

For this analysis I shall consider a basic hypertext system that links various sections of information of different types through specified links and hot text. I shall cover some of the possibilities for improving on this after I have discussed some of the problems with this basic system.

Academics have supported browsing as a way of learning (Jonassen & Wang 1993; Spiro & Jehng 1990). With users following their own links and investigating areas which they find interesting they have some ownership of their learning. This added responsibility may be good, but there are some problems too.

The first set of problems relates to the learner's navigation of hypertext. A user can easily get lost or disoriented in hypertext which may be quite large and consist of information of which they often have little or no knowledge. Making useful decisions about their route in such an environment is difficult. Taking a route may lead them to somewhere they did not expect, or the text may be structured in a way that they had not anticipated. These problems are compounded as the number of alternative options increases. Hammond (1993) compares the experience to that of a computerised adventure game where users are uncertain about what can be selected and what will happen next - "but at least it could be something interesting and unexpected".

The navigational problems relate to problems of the learners' task goals. As Hammond points out "learning can hardly be effective if learners merely ramble through the knowledge base in an unmotivated and haphazard fashion" (Ibid.:52). The addition of learning goals may direct the students' learning to some extent, but can give rise to a further difficulty as students find it difficult to match task goals to the hypertext structure. They are unable to locate a specific bit of information and are unaware of how and where that information fits into the structure, or of a route to get there. Learners with ill defined goals may search the environment for clues of what to do next. Learners who are left to browse in this way without guidance may be unable to ask themselves the right questions to motivate choosing the correct routes.

A further important problem with browsing hypertext systems is the lack of user interaction and engagement. Hammond (1993) points out that the "Material is there to be viewed, sure

enough; but there is nothing to guarantee that the learner adopts a productive strategy for understanding and remembering.”. No part of browsing requires the learner to actively think about the material or the structure.

To overcome these weaknesses in navigation in resource based learning , it is important to know “(1) Where you are in the network and (2) how to get to some other place that you know (or think) exists in the network” Cronklin (1987). A third point to add is the need to know where have you already been and what have you already seen. In some applications it is also important to know how much have you done and how much more there is to go. Consequently resource based material comes with various maps, searches and indexes.

Hammond (1993), in response to Ambron (1988) who talks about the way learners can “browse, annotate, link and elaborate on information in a rich, non linear, multimedia database”, asks “Do learners, or indeed teachers, really want to do this?”. There are situations in education where there is a best path through the domain. Perhaps the users’ effective freedom should be limited to a smaller choice of routes and activities. For example, where the sequence of learning is important (each successive block building on previous ones) , or where the educator desires that the student learns a specific point of view

Didactic systems need not diminish the learners’ control over learning strategy. Many provide guidance to the learners based on some measure of their progress and direct the learner to sections specific to their needs.

Different learning situations and different subject matter will require access to the material in different ways. Resource based material is useful as a multimedia reference for the production of student work or as a tool to find some specific information or to achieve a clearly specified goal. The success of the Riding and Chambers (1992) study is perhaps due to having set the students specific questions to answer, though these questions aimed to investigate different learning activities (see the ‘Computer Assisted Learning’ section from earlier in the chapter for details).

There is a continuum between resource based learning and strict didactic systems. The style of any educational system will depend on that particular application’s goals: “Different learning situations may require quite different tutorial approaches and facilities” Hammond (1993). The need for clear structure and defined goals is common to the success of these systems.

2.3.3. User Interaction / feedback

The notion of interactivity has already been raised a few times in this chapter. What does it mean to be ‘interactive’? Can multimedia manage this feat? And if so, how?

Plowman (1988) suggests that the word 'interactive' in 'interactive video' "suggests dialogue and active relationships between *people* to promote learning in a positive way" [italics mine]. She goes on to argue that perhaps the term 'interactive video' is often a contradiction in terms for many of the programs produced since not enough consideration is given to learner dialogue. She believes that IV is better used as part of an active learning curriculum, rather than there being an interactive relationship between the student and the system.

If we consider Floyd and Floyd's (1982) definition of interactive video: "...any video program in which the sequence and selection of messages is to be determined by the user's responses to the material" then the system does respond to the user's actions in that it controls the sequence and selection of material based on the actions of the user. This is a step forward from the system responding to the user's selection of material as might happen in browsing a database or hypertext.

Jacobs (1992) states, "The computer enables this mix of media [in multimedia] to be interactive, as opposed to current broadcasting and publishing practices which for the most part are aimed at a passive audience". Though it is fair to say that broadcasting and publishing are essentially one-way, readers of such material still remain active (Fiske, 1987), this activity does not make reading a book an interactive experience. It is the two-way activity that makes the medium interactive. If the computer is able to make an active response to the user and so create a kind of dialogue between the two then maybe multimedia can earn the title 'interactive'.

The nature of interaction between the learner and the medium will vary depending on what is being taught and the design and capabilities of the system. Romiszowski (1993) uses analogies of non computer dialogues or conversations to identify four types of interaction which can take place between human and computer. He equates the four types of interaction to existing instructional and educational methods.

The first type is between an instructor and student. The instructor gives a practical demonstration and explains key points. The learner is expected to follow the demonstration and explain the key points back to the instructor. The instructor gives feedback to correct the learner's performance. Romiszowski relates this interaction to the methodology used in linear programmed instruction.

In the second comparison Romiszowski makes, the instructor not only corrects the student in the areas where their response was below standard but will also show alternative examples, analogies or other tactics. He suggests that this example of human interaction is analogous to the branching model upon which most computer assisted instruction is based.

The third example of interaction is where the conversation is more student-led. The student presents questions to the instructor who supplies the answers. The instructor is the

information resource responding to the students requests which are based on the student's understanding of the topic and current needs. Romiszowski relates this to a student-led search of hypertext or hypermedia.

In the last example, the instructor, in responding to a student's question, takes the student beyond the original question. The instructor probes the student's current understanding and approach and extends the student's knowledge with challenges, questions and extra information. The instructor can decide how best to present the topic to a student on the basis of knowledge of the domain and of the student's performance so far. This is analogous to the ideal intelligent tutoring system, though such systems have not been fully realised yet.

Romiszowski's appraisal of interaction relates to the depth of the learner's processing. Whereas the first interaction described may be sufficient for some tasks, other more complicated material would require the student and teacher to have an insight into each other's thinking. In the latter case, the fourth interaction example may be able to provide a deeper level of processing.

Gagné lists 'providing feedback' as an important event of instruction, but media of the time were unable to provide feedback beyond "defining the objectives of instruction clearly to the learner, so that he will become aware immediately when he has attained each specific goal" Gagné (1971). The notion of feedback is still central to learning, but now interactive media are capable of providing a more direct response to the learners' actions.

Feedback is central to the idea of interaction, as without some kind of feedback learners would be unaware of the consequences of their actions. The feedback to an action gives some kind of information about how the action affected the system. Given the right feedback the user can adjust their next action accordingly. Laurillard (1993) identifies two forms of computer response or feedback - 'intrinsic' and 'extrinsic'.

Intrinsic feedback is feedback that is a natural consequence of an action. Clear examples of intrinsic feedback are easily found from the things we do every day. Laurillard uses examples of a child's actions while playing in water, of filling, pouring and emptying. The intrinsic feedback of an action may not be an inevitable consequence, but only a natural one - Laurillard uses "correcting pronunciation" as an example, since it "is a social norm and feedback of this type is natural and probable" Laurillard (1993).

Extrinsic feedback does not happen as a natural consequence of the action, but as an external comment on it. Extrinsic feedback does not happen at the level of the action, but at the level of the description of the action. The child who receives intrinsic feedback, from the first example of water play, by seeing the vessel empty onto the carpet, may expect the extrinsic feedback, on the level of the description of the action from its parent, of disapproval. Many

actions require more helpful extrinsic feedback than 'right' or 'wrong', in these cases the feedback can carry information for the learner on how to adapt their action.

For a multimedia program to be considered as interactive, something within the program needs to change as a result of the users' actions, so that the user is doing more than just browsing. As a result of the students' actions there must be some form of feedback. Without this feedback the students cannot know the consequences of their actions and so can not adjust their consequent actions accordingly.

Designers of multimedia must consider which feedback they should give the learner since feedback forms the computer's side of the human/ computer dialogue. The right feedback can encourage and guide the student positively. Incorrectly thought out feedback on student actions may add to learner confusion as to the state of the system, and the progress of their learning.

Educational multimedia and technology needs to support the learner. Multimedia is a medium over which the learner has control and authority. If users are to be able to learn from it they need a system which works as they expect, allowing the control they need and clear feedback on their actions.

2.4. Structure of Educational Media

2.4.1. Video Grammar

Video and television are integrated media, combining sound, colour images and movement. The long history of their development should provide a valuable basis for understanding multimedia. As Heppell (1993) points out "Much of the early pioneer work in integrated media owed a considerable debt to the narrative function borrowed from TV and cinema." From a study of video's structure and development it may be possible to learn about and guide the development of multimedia.

This thesis sets out to investigate how video can be used in multimedia, and how this new use is different from its existing use in education. In order to examine both these questions we must first look more closely at how video works and how it is structured. We can then re-examine these questions from the perspective of multimedia.

Television and film are modern media, and it has been possible to chart their development in some detail. Today we see many different forms and genres of film and television, from education and documentary to soaps and westerns. Viewers have no problem using and following the media. In the early days of film, the conventions by which we all understand film had not been developed and even simple cuts would confuse the audience. "A society

agrees or is taught to interpret some symbols with uniform meanings of everyone belonging to that group" Arijon (1976). Over time and thanks to the adventurousness of the early film makers, a language of film has developed, and is still continuously changing. It is this language that is often referred to as the grammar of film and television. Like television and video, multimedia is a new medium with a grammar of its own. As DeBloois (1982) observed, interactive video "...is not merely a merging of video and computer mediums; it is an entirely new medium with characteristics quite unlike each of its composites". Since it is such a new medium with a grammar of its own, readers of the medium will need to develop reading skills specifically for this medium, even though users of multimedia will already have reading skills for the component media. Plowman (1993) contends that "we are not able to transfer the 'reading' skills we have acquired from these media directly because this new combination has given rise to a new form of text with which we need to become familiar". The grammar of multimedia will develop from extending the grammars of its component media just as the grammar from early film developed from people's understanding of theatre.

What, then, are the elements of television and film grammar? This question is not easy to answer due to the nature of this grammar. While the audience has no difficulty understanding the language of film, it is not a language in which they can express themselves - even if they are given the necessary equipment and the knowledge to operate it. In fact film makers aim to hide film's construction from the viewer. When talking about a simple cut, Thompson (1993) says "when it is made correctly it is not consciously noticed".

There is also no formal description of the grammatical rules which form the language of television, though a number of books (Arijon (1976), Thompson (1993), Davis (1969)) have tried to describe elements of it so that the production skills involved may be passed on. On the specifics of film grammar, Arijon (1976) points out "Few film makers have the ability to rationalise their creative mental processes in the form of written, analytical theory." Unlike the grammar of written English, film grammar does not have well defined rules and is constantly in flux. It is perhaps because of the way in which video's grammar is kept obscured from the viewer and because of the continuous adaptation and breaking of conventions that it is difficult to define a standard grammar analogous to that of ordinary language (Ide, 1974).

It is possible to define the basic elements of film production as camera, lighting, editing, acting etc. These elements can each vary in a number of ways such as: camera position and movement, lighting colour and brightness, editing techniques, acting style and so on. Film grammar combines these elements and their use in film production, to produce a common socially agreed meaning.

Little research has been carried out to distinguish the elements of video and film grammar which have changed as a result of video's new situation in multimedia, what new grammatical elements exist, what happens to the old ones, and the creation of a new grammar of multimedia. Indeed there has been little work that deals practically with video grammar in education. Lin & Creswell (1989) examine the effect of the direction of the presenter's gaze and Bagget (1987) examines the role of an instructional film in teaching the procedure of constructing a model. Baggaley (1980), through a series of experiments, looks at various psychological functions of television presentation from image effects such as peripheral detail through to musical accompaniment in a documentary film. These studies tend to be too specific, relating closely to the particular experimental set up and therefore offering little 'theoretical' basis from which to develop an analysis of the role of video in multimedia.

2.4.2. Narrative Film Form

The previous section discussed the idea of a grammar for the language of film. This section looks at how grammar is used in film to create the film maker's or educator's arguments. A much simplified view of film form is the idea that a film's content must be carried in some way. Bordwell & Thompson (1986) use the analogy of form being like a vessel, such as a jug, that holds the content and shapes it, though they go on to discount this as simplistic. Since film form is intertwined with content there is a continuum between the two. They describe five types of formal systems: categorical, rhetorical, abstract, associational and narrative films. The first four are regarded as non-narrative forms. They have had little use on television and many people are not familiar with them, though because they are non narrative, equivalent forms may become more common in multimedia in the future.

The idea of narrative film form is much more commonly found and understood and so is of particular interest to educators and multimedia producers. "Narrative structures serve well to introduce new material or to deliver an overview of contents" Heppell (1993). Bordwell & Thompson (1986) define narrative as "a chain of events in cause effect relationship occurring in time and space". Causality and temporality are the defining features of narrative, and are present in all narratives. Cause and effect link a sequence of events (e.g. film shots) together to become a narrative. Even without cause and effect it may be possible to see a relationship or imagine a story between the same events yourself but otherwise the sequence of events will appear to be random to the viewer. In fact the ability to extract some meaning from a series of events that is not linked by a narrative structure is how many of the non narrative film forms, such as associational and categorical films, work.

If the essentially linear relationship of cause and effect over time is the basis of a narrative then how can narrative be represented on an interactive medium such as multimedia?

Plowman (1993) draws attention to some of the differences in interactive video that will affect the use of narrative. Although her comments relate to IV they can be equally applied to multimedia. The narrative structure of interactive video differs from other media because:

The combination of video, text, animation, freeze-frames and voice-over is unique;

Group discussion among IV users is an integral part of the experience;

Learners' control of the path through the text leads to multiple narratives;

There is often a facility for repetition of sequences;

There is no fixed running time;

It is often possible to call up 'help';

It is task-oriented. Plowman (1993)

These differences make multimedia different from traditional media with which we are accustomed to following narratives. The key difference is that the user has control over the selection, sequence and pacing of the material within the constraints of the framework that the program designer has set up.

2.4.3. Argument construction in video

Koumi (1991) sets out a framework for writing and evaluating scripts for narrative educational television (fig 2.1). If this lays out a suitable framework for how educational television should and does work then it should be possible to look at this later with interactive / multimedia video in mind.

The three usage dimensions in section A are fairly self explanatory. The first dimension section A.1 of the table 'Target Audience' are points that any educator or program maker must consider in designing their material. Sometimes, for the medium of television it is as well to point this out since unlike material designed for some educational use there are extra levels of alienation between the educator - video producers/ editors and the viewer. Section A.2 points to the consideration of how the video fits into the courseware as a whole - what complementary material accompanies the video and what material the video complements. The educational objectives (A.3) must be considered in the light of both the learning context (A.2) and the particular strengths of video detailed above.

The structural considerations in producing effective narrative educational video lie around points B.1 - B.4. Koumi (1991) asserts that B.2, B.3 and B.4 "are well-known by teachers: 'Tell them what you'll do, do it, tell them you've done it'." Principle B.5 'Connect it' though less frequently verbalised by teachers is widely practised, and is especially important in video.

Narrative Screenwriting for Educational Television Koumi(1991)

A. THREE USAGE DIMENSIONS

How is the programme to be used: by whom, in what context, for what purpose?

1. Target Audience
a. Culture
b. Age
c. Commitment: general/student body
d. Previous Experience / Knowledge
e. Facilities, e.g.: owns/shares a TV?

2. Learning Context and Complementary Learning

- a. Other media: e.g. class teacher, other TV, audio, print other students, computer
- b. Pre-Work, post work
- c. TV vs. stop-work-start video

3. Educational Objectives

- a. Affective (feeling, appreciations) e.g.: reassure, fascinate, personalise
- b. Motivational (urges) e.g.: mobilise, stimulate diligence
- c. Experimental e.g.: concretise, explore, demonstrate
- d. Cognitive e.g.: knowledge, concepts, strategies

B. STRUCTURE.

Each chapter of the story

1. Make them want to know	Hook (but no false promises) a. Appetise / Create suspense b. Surprise / Excite / Dramatise
2. Tell them what you will do	Signpost a. Set the scene / introduce b. Distant Signpost: What's coming? c. Chapter Heading: What's next? d. Focus: What to look for
3. Do it: with sympathy	[T] Texture the Story a. Non-Linear / Non-sequential b. Vary Format c. Vary Mood / gravity d. Structural Pacing
	[R] Reinforce a. Repetition b.. Re-exemplify c. Compare / Contrast d. Dramatic Climax
	[S] Sensitise a Seeding b Consistent Style c. Music Style / Occurrence by Design d. Signal Change of Mood /Topic
4. Tell them what you have done	Consolidate / Conclude a. Recapitulate b. Summarise Salient Features c. Generalise / Extrapolate d. Chapter Ending
5. Connect it	Link (make story hang together) a. Content-Link Between Items b. Story-Link / Hand-Over / Pick-up.

C. Sympathetic PICTURE-WORD Composition

1. Producer Into Viewer's Mind: what is the viewer thinking / looking at? a. Words reinforcing Pictures & vice versa b. Optimize Load, Pace, Depth c. Enhance Legibility / Audibility d. Grammar of TV e. Communicate assumed external knowledge
2. Producer Out of Viewer's Mind Don't blinker / Allow mental elbow room <i>MINDFUL learning by a RANGE of viewers</i> a. Words NOT DUPLICATING pictures b. Pause for Contemplation c. Pose Questions d. Don't Mesmerise e. Reveal Geography f. Reveal Concept-Environment g. Professional Integrity

B.1: 'Make them want to know' is also something any good teacher aims to do. Video, when properly produced, can also do this very well.

The hook (B.1) is an important part of television production, the aim being to hook the viewer with an idea or interest and then keep them hooked throughout the programme - and normally, for broadcast, keep them between programmes too, (Fiske 1987). The need for these types of motivational tactics is not the same for educational television since it is hoped that the student already has some interest in following the program. Hooks within the programme are still important if it is necessary to keep the learners' attention and especially if the educator desires that the learner sympathetically follows the argument put forward.

Signposts (B.2), (again fairly self explanatory) are a very important function especially in educational video. There are a number of ways to lay out what the viewer is to expect. This can help the viewer focus their attention on the points that are important and allows them to see where the programme is heading. This also has a motivational role since signposts can act as hooks too.

The third section in Koumi's framework for educational television suggests considerations involved in the presentation of the argument. In the first point in this section (B.3) Koumi talks about considerations in presenting the argument through video and the need to do it with sympathy. In the section 'texturing the story', he only describes the benefits of providing 'Structural Pacing'.

The second part of section B.3 is more self explanatory. The need to repeat, re-exemplify and contrast points has much in common with other media.

The last section of B.3 deals with the idea of sensitising the learner. The aim is to be able to direct the user's sympathy and attention to the material and points that the educator feels are important. This can be done in ways such as using a consistent style to allow associations between different points, careful use of musical styles and sound effects, and changing the mood and approach.

After presenting a key argument point to the learner, section B.4 deals with the importance of telling them 'what you have done'. At the end of a video section an effective educational video program should help the viewer consolidate what has gone before. Koumi draws the parallel of closing the book at the end of a chapter: the viewer needs to know that the argument point has been dealt with and can be "labelled and filed away in the viewer's mind, which is now cleared to receive the next topic". Other types of consolidation may go back into the section to recapitulate or summarise.

Sections or arguments in a video need to be linked together in order that the story flows and that the overall argument and structure make sense. Also if the connection between the

previous section and the next is clear then the viewer has saved some effort trying to do this themselves. This effort can be better applied to interpreting the key points of the new section.

In the final part of his framework for narrative screen writing, Koumi considers the relationship between the viewer and the video producer and educator. The producer “has to ‘feel with’ the viewers, trying to predict what they are thinking and looking at on the screen” as well as having “to ‘feel for’ the viewers as thinking human beings who must not be totally led by the nose but should be given the opportunities for independent thought”.

To work with the viewer the producer has to use pictures that reinforce the words and vice versa. The script cannot be written before the appropriate video footage has been selected, or the video sequence selected before the words are written. The process has to be one of negotiation and revision. The producer must work within the learners’ understanding of televisual codes - ‘Video’s grammar’, and consider the users’ attention span and ability to accept their load, pace and depth.

In contrast to this, the producer must also accept that no two viewers are the same and must cater for different abilities and interpretations. The ways of doing this are listed in C.2. The viewer must be encouraged to contemplate and evaluate the material since this reflection and processing is part of learning. Koumi suggests one way of doing this is by not allowing the words and pictures of a sequence to match exactly. If during a sequence the narration matches the action exactly then this is uninspiring and directs the viewer to one reading. If, on the other hand the information from the visual and audio gives slightly different perspectives then in reconciling the two the learner is encouraged to be more analytical. This approach also allows more room for viewers with different experience and pre-knowledge to read the ‘text’.

Koumi acknowledges that this framework is untested, but it does represent his and other producers’ work. Much of it is also in accord with the work on grammar and editing by such writers as Arijon (1976), Davis (1969), and Thompson (1993). The framework is certainly a useful guide to how many educational television programmes are designed and work, and should be useful therefore in determining some of the issues involved in how video may be used in multimedia.

2.5. Multimedia Design Theories

2.5.1. Instructional Design

A multimedia environment is able to support a range of different ways of allowing the student to learn. So far we have discussed the potential of the component media in multimedia. Here

we shall look briefly at how learning takes place in order that ways of using multimedia in education can be examined.

Gagné (1971) details the important events generalizable in instruction and learning of facts. His analysis of learning has been generally accepted as a foundation by many educators of today. Gagné lists the six most important events as the following:

1. Gaining and maintaining attention. Gagné suggests devices such as change, novelty and appeal to dominant interests, as being ways to attract and maintain attention. In order to do this it is now possible to add activities such as interactive demonstrations and solving problems.
2. Insuring recall of previously acquired knowledge. The interpretation and subsequent integration of new knowledge structures with the old requires the constant review and updating of existing knowledge. Multimedia can present the same information with a variety of media enabling greater scope and variety .
3. Guiding the learner. Gagné talks about the verbal or visual material that provides “cues” or “hints” towards new principals and refers to Ausubel’s (1963) ‘organisers’; the idea being to provide “the learner with a meaningful structure before he attempts to learn a new principle” and to the use of questions. This stage relates to the use of attainable learning goals based on the structure of the material. These goals are either set by the educator (within the material), or are defined by the skilled learners themselves. The more explicit structure that multimedia offers can assist learners to achieve their goals and to set new ones. The adaptive possibilities in multimedia and its many media offer a larger palette of “cues and hints” that are more capable of guiding the learner towards new principles.
4. Providing feedback. Learner’s need feedback on their accomplishments in order that they can gauge their progress. Gagné suggests that the feedback comes by way of either the educator or learner defining clear objectives for learning that are evident when they have been attained. He notes that textbooks and other media of the time badly neglect this instructional function. Interactive media has vastly widened the scope for useful feedback. This will be discussed later elsewhere in this chapter.
5. Establishing conditions for remembering the learning through practice. Gagné suggests that there needs “to be a carefully designed series of problems to which application of the newly learned principle is made”. He relates this process to Ausubel’s (1963) “integrative reconciliation” in which new ideas are compared and contrasted to related ones which have been learnt previously. It is this sort of processing of material that is associated with the depth of processing dealt with later in the section. Multimedia makes possible the integration of computerised simulation, where the learner is able to test newly learned knowledge in a simulated environment. Knowledge can also be practised in a series of

computer assessed tasks, and weaknesses in the students' performance can be targeted with extra tuition or questions.

6. Assessment of outcomes. Gagné recommends that the "outcomes of learning and remembering need to be assessed frequently" with perhaps a "five minute daily or weekly quiz". Gagné (1971) does not make clear the benefit of these quizzes to the learner, but certainly it exists in the later review with consolidation of learning (Buzan, 1989). The monitoring of a student's progress is now not only possible through computerised tests, but can be recorded during the time that the learner works with the system.

It is not only important to determine what learning activities are important and how multimedia can support them, but also to understand how students learn from media. The future classroom equipped with access to large multimedia databases will require even less emphasis on remembering large amounts of factual information. Instead the mental tools to access and process the available information are what will be necessary for the students to learn. Such skills as problem solving and lateral thinking are transferable. Time spent on specific, and often changing facts could perhaps be spent more usefully elsewhere. Since such skills are desirable how can they be promoted in multimedia?

Salomon (1979) takes a closer look at how students learn from different media and suggests how different media may have different cognitive advantages. He argues that different media have different symbol systems that code the educator's message. Different symbol systems are appropriate for encoding different sorts of information. Decoding the symbol system activates different skills depending on the learner's existing skills, and on the similarity between the learner's existing internal coding methods and the original external coding method. This may make the internal re-coding and knowledge extraction easier or harder, or may enable the learner to gain different elements of information. Once the material has been re-coded it can be elaborated internally. The more elaboration, the more the new material will connect with existing schemata, so making more memory traces as well as enriching the accrued meanings.

Perhaps of importance to multimedia is the idea of explicit and implicit learning. Hammond (1993) describes explicit knowledge as knowledge that can be expressed directly by the individual, either by using words or some other form of expression. Facts and rules are explicit knowledge. "Implicit knowledge cannot be described directly, but its presence can be inferred from the person's actions" Hammond (1993). Skills and knowledge of structures are an example of implicit knowledge. Hammond relates the two types of knowledge to the two forms of knowledge representation: declarative and procedural. Declarative knowledge (knowledge of facts) is expressed explicitly, and procedural knowledge is normally expressed implicitly and learnt through performance. Of interest to multimedia producers is the idea

that by browsing or working with a program the learner can learn implicitly as well as explicitly. Unlike more conventional media, multimedia supports a far greater range of ways of representing implicit knowledge since it allows the practice of procedures and includes video that is able to display actions and events in a way that other media cannot.

The level at which a student processes the material to be learned is of importance to educators. "A cursory browsing of materials will result in shallow processing, few mental elaborations and poor retention" (Hammond, 1993; 54). Marton & Säljö (1984) suggest different levels of learning were responsible for students having qualitatively different ways of understanding the same text. Their conclusions come from a qualitative study in which they gave students a passage of text to read and then followed it up with questions about the content and to assess how they tackled the task. It transpired that some students were focusing just on the text or what the text was about, while others thought *beyond* the text to consider the intentions of the author, the main point, and looked to what conclusions could be drawn. During the design of courseware the educator needs to encourage the latter, deeper, approach rather than the former, surface level approach. The learner needs to be able to recognise relevant information and should be encouraged to process it at some depth.

Also of importance in the design of multimedia is task orientation or the setting of learning goals. The user's interpretation of the alternatives and information offered by the computer will depend on the user's own objectives and prior knowledge. Consequently the availability of information is not enough since misinterpretation can still occur. To counter this, Hammond (1993) suggests that, as far as possible, learning materials should be structured in a task-based fashion. Jonassen & Wang (1993) also note the importance of setting goals in the use of hypertext. Although the technology of hypertext is a form of information retrieval, this is not sufficient for learning. "When the goals of accessing information require deeper processing, then deeper processing is more likely to occur" (Jonassen & Wang, 1993).

The students may recognise the goals which the teacher sets for their learning, but may have different aims. These could include the completion of sufficient work to satisfy the teacher in order that they are able to do something else. Even if the more dedicated learner shares the same goal as the teacher, their understanding and interpretation of what is necessary to attain the goal may well be different.

The educator can only go so far in constructing and laying out a structure and argument to enable the student to grasp a particular conceptual element of a topic and can only facilitate learning, ensuring that the material is of a sufficient pedagogical standard. The students must be prepared to contribute themselves by creating their own links to their experience, and by reflecting on the structure of the teacher's discourse, thereby practising the representation of their description of the world in the relevant academic language (Laurillard, 1993a).

2.5.2. Structural Design

This chapter has so far looked at the various component media, the user's interaction with the media and includes an analysis of the structure of film and video. This section takes a closer look at the structuring of the pedagogical material.

Like video, traditional media in instruction have been largely linear (e.g., textbooks and lectures) (Spiro, Jehng, 1990). This linearity of delivery does not necessarily equate to linearity of subject matter or argument. Whalley (1990) points out that though text is superficially linear, authors may create rich and complex relational structures with forward and backward references and adjuncts. But even with this non-linearity of argument structure, traditional media have had to deliver the argument through their inflexible linear constrictions. Computer assisted learning systems such as multimedia allow non linear access to a subject domain. This of course does not mean that the learner is subjected to more than one point at a time. Indeed the learner's path through material will mean that they encounter one point after another as in existing linear texts, but this time the path is of the learner's choosing. Spiro and Jehng, (1990) point out that it is likely that the learner will "revisit the same content material in a variety of different contexts, with each visit bringing out additional aspects of that content's complexity that are missed in the single pass of linear coverage" (Ibid.: 163). They suggest that this type of 'random access instruction' is particularly suitable for complex content.

Linear media are suitable when the subject matter is well structured and fairly simple, but as the content increases in complexity and the structure becomes unwieldy then important information may be lost. In fact, Spiro and Jehng advocate this; their random access instructional system is due in part to the application of 'Cognitive Flexibility Theory'. The theory suggests that learners have the ability to spontaneously restructure their knowledge in many ways as an adaptive response to changing situational demands. It states that this ability is a function of both the way in which knowledge is represented (along multiple rather than single conceptual dimensions) and the processes that operate on those mental representations. This restructuring of knowledge is supported in their 'random access instruction' hypertext example which is a complex literary comprehension of Orson Welles' 'Citizen Kane'. The program seeks to let the learner explore and understand the multiple sub thematic (and sometimes contradictory) themes that the film contains.

The program itself is structured by way of a number of mini-cases, each representing a focal learning point. The overall structure of the links between cases is undefined and flexible in order that the learner can establish their own links, thus avoiding "the premature 'closing down' of the interpretative process as soon as one account is identified"(Ibid.:186). This

deconstruction widens the possible reconstructions as learners chart their courses through the material.

The hypertext allows the learner to approach the material from many directions; each exploration path producing a different interpretation of the text. This multi dimensional reading of the same text is supported by multi dimensional conceptual representation of knowledge in the learners who actively restructure their knowledge for each different approach on the material. The result of this type of learning is that the learner is able to see *Citizen Kane* from a large number of valid perspectives. Each new mini-case adds to “a kind of ‘stereographic’ representation - the multidimensional fullness of the content is increasingly approximated with each additional perspective that is presented”. In addition to this, the learner also builds up “a picture of the interrelations among the thematic perspectives” and a “deeper understanding of complexity and nuance, understanding that provides learners with a basis for going beyond what was explicitly taught.”(Ibid.:203).

Unfortunately such claims have not been substantiated yet with experimental work. It is possible to see how the described system might function for *Citizen Kane*, but even among films *Citizen Kane* is often selected because of its complex structure and polysemy and as such it is atypical. Though this type of reading of a text may allow many interpretations, students of different backgrounds and ideologies will still come away with a different set. Educators may want more control of specific readings of a text over others. Indeed often, even in complex subject areas, specific interpretations may be desired. In such situations there may be the need for more explicit sign-posting and structure, though such programs still want to facilitate the learner’s freedom in tracing their own most suitable route to that point.

As the material becomes more complex and the possible ways of accessing it increase its structure needs to be clear. If the learners are to navigate through unfamiliar knowledge then it is fair to expect them to need some guidance, if they are to know which direction to go, and are to choose a suitable destination.

The structural aspects of hypertext have been discussed in the ‘Computer Assisted Learning’ section earlier. The claims that hypertext structure mimics the internal semantic knowledge of the expert, and that through browsing of the hypertext the student too might integrate this structure into their own knowledge (Jonassen, 1990), are bold and as yet unproven.

From a study of how learners understand video programmes, Laurillard (1991) found that learners understood a text in terms of its examples and component points, rather than having a full understanding of how these elements relate to the main point. She suggests that this may be due to the learners being unable to clearly discern the structure and ignoring cues that would reveal it - assuming a linear rather than hierarchical structure. From this study Laurillard finds that learners were more able to distinguish the main point in programmes

that were structured so that more time was spent dealing with it, or in programmes that returned frequently to the main point.

Having examined how learners acquire structural knowledge while working with semantically structured hypertext, Jonassen & Wang (1993), (similarly to Laurillard) note that learners recall structural "micropropositions (detail) more readily than macropropositions" (p. 18). They found that by merely presenting structural information learner's structural knowledge acquisition did not increase but this could be achieved by making learners focus on structure during their work. They also note that this awareness of structure should not have to be directed but should be one of the skills of a literate reader of hypertext. Experienced readers of hypertext may learn to take note of structural information as well as detail.

It appears then that an explicit structure is not enough for learners to have an understanding of the whole argument but that the text needs the right type of structure (Laurillard,1991). More reader experience of reading this type of material may also be of benefit.

2.5.3. Media Considerations

From the discussion above it is clear that each of the media has particular strengths and weaknesses. The ideal of multimedia would be to bring all these component media together in the creation of a new medium that draws from the particular strengths of each of its components. The result would not be a new medium that would automatically solve all educator's problems; far from it, it would just be a new and particularly flexible medium with its own strengths and weaknesses. Within a multimedia environment a key issue would be which of the component media should carry which part of the educational argument. This problem of media selection is one that has been discussed at some length, since as Gagné (1971) points out "it has long been recognised that different media play different roles in learning".

Romiszowski (1993) lists three beliefs that educators hold when considering the educational benefits of a variety of media in education:

"different learning modalities of students can be matched in some way to the provision of audio, audio-visual and textual versions of a particular topic."

The content of the topic to be taught requires or suggests a variety of media.

Certain media can teach more effectively than others.

A lot of work has addressed the issue of whether a particular medium teaches a particular topic to a particular type of student any more effectively than another medium. The many comparative studies that have been undertaken have so far not conclusively shown one

particular medium to be intrinsically more effective than any other. Spencer (1991) observes that more often than not, no significant difference is found in the learning outcome. Even the meta-analysis of these studies has shown little significant difference between the effectiveness of media. From his study of the meta-analysis, Clarke (1983) concludes in his now notable statement: "The best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition. Basically, the choice of vehicle might influence the cost or extent of distributing instruction, but only the content of the vehicle can influence achievement". Instead he suggests that any effective change in the comparison of media is due to differences in the instructional design and not the media (Clarke, 1985). This implies of course that comparative studies should keep the instructional design constant. Both Romiszowski (1993) and Spencer (1991) disagree with this notion; Spencer suggests that it is a mistake to compare 'like with like in terms of modes'. As Romiszowski (1993) points out "A given learning outcome may be achieved more effectively by a superior instructional design and, occasionally (though not always), the superior instructional design may require the use of specific media that have not been used in previous instructional designs.". Gagné (1971) also notes "No single medium possesses properties which are uniquely adapted to perform one or a combination of instructional functions. Instead, they all perform some of these functions well, and some not so well. The arrangement of instructional conditions is still the key to effective instruction."

Rather than approaching this issue from the point of view of investigating a particular medium or technology, Laurillard (1993a) first looks at the necessary elements of the learning process and elaborates this to arrive at the types of learning activities that a student needs to carry out in order to gain a conceptual understanding of a topic. The different media are then contrasted to see which of them support these learning activities.

The analysis shows that no single medium (print, video, computer-based tutorial, teacher-student discussion) supports all the elements of learning. Laurillard suggests that the relative strengths of each media can complement each other, allowing the educator to "target each medium on the aspect of the learning process it best supports" (p.91).

The work of both Romiszowski (1993) and Laurillard (1993a) suggests two issues that are important in the examination of a medium such as multimedia. First it is necessary to determine what the actual strengths of the medium are and which student learning activities these specific strengths of the medium support. And then with the strengths of the medium in mind, questions of instructional design must be considered: "what presentation or manipulation of available text and images make the most sense in terms of desired learning outcomes?" Romiszowski (1993).

2.6. Conclusions

It is clear that multimedia is a new medium that couples the strengths of its component media with the flexibility and possibilities of computer control. Being new, it will have a grammar of its own. Although multimedia's grammar is derived, in part, from the grammars of the constituent media, users and designers will need to work out how the new grammar will work.

Since video will play a large role in multimedia in the future, this chapter has looked at: how video has been used in education; the way in which students learn from video; video's strengths and weaknesses and how the educator can construct an argument using video. It is hoped that this investigation will prove useful in determining how designers can construct and integrate video into multimedia effectively for education.

In this chapter some of the issues involved in learning from media have been examined, particularly considering aspects such as user control and interaction which are related to the design of media. These aspects will not only be useful in determining video's use in multimedia, but in discovering more about how multimedia itself works as a new medium in education.

Chapter 3: TerminalRISK

3.1. Introduction

This study is preliminary for the research. Since there has been little research in the area of how users might learn through a video grammar, this preliminary study 'tests the water' to see where the key issues lie and how they might be investigated. The literature review showed that there was little research into or evaluation of interactive video in education that focused on how the users can benefit from this new medium. This chapter goes some way to correct this by evaluating a successful interactive video disk that is used by a large company.

Since the literature survey raised a number of questions about the use of video and narrative in educational interactive media, the evaluation pays particular attention to the role of video in TerminalRISK.

TerminalRISK is a large program that deals with a very complex area. This evaluation looks at how the interface worked, how successful it was and how the users of the program worked with it.

Since this chapter is an analysis of TerminalRISK, its use of video and the flowcharting sections, it points out and focuses on problems. This is not an indication that TerminalRISK is problematic. Indeed Price Waterhouse have found that the program very successfully fulfils their objectives and the industry has recognised TerminalRISK's success by awarding Price Waterhouse a British Interactive Media Association (BIMA) award for 1993.

3.2. Outline of the Study

3.2.1. What is TerminalRISK

TerminalRISK is a video disk training programme designed to train users to identify possible weaknesses in computer systems that could cause problems in the running of the business - or be exploited criminally for profit or sabotage. The programme teaches a five stage approach and is presented in those five stages, each stage consisting of four sections: 'Tutorial', 'Tasks', 'Bytes', and 'Report'. Users of the system should be prepared to spend a whole day working through the entire disk properly. It is possible for the users to save their positions and to return to complete the programme later, but this is not recommended.

The five Tutorial and Bytes sections contain a video narrative that unfolds during the day, as well as computer graphic sequences that describe the process of each stage. The video and

graphical sequences in these sections each last around two minutes. The task section involves the user executing the principles of the current stage on a case study. The computer checks the progress of the learners as they complete the tasks it sets on screen. The report section clarifies the knowledge used during the stage.

As well as the video that accompanies the five stages there is a video introduction and conclusion both lasting approximately five minutes.

Accompanying the video disk is a large folder of printed material. The contents of this folder form the case study notes of a fictitious auditor who has since disappeared. The learners must use and analyse this information applying the techniques that the program teaches. The program also contains information about the case study (such as the organisational structure of the company concerned). Not all of the printed material is useful - in fact some of it is deliberately out of date as it might be in a real situation. The program urges users to take notes during the day, and they must complete a written questionnaire / test once they have completed the program.

3.2.2. Users

The users of TerminalRISK in this study were all auditors who had worked with Price Waterhouse for 2 years or more. They were expected to work with the program as part of on-going training and before they undertook work in security auditing on Computerised Information Systems (CIS). All the users who took part in the study had at least two years' auditing experience with Price Waterhouse; some were familiar with computer systems as users, others had had little experience with computers at all.

The main users of TerminalRISK fall into this category, but these are not the only users. The system is used throughout Price Waterhouse to familiarise auditors with the potential risks associated with computer systems. The program is also hired or bought by third parties for their own training needs.

3.2.3. TerminalRISK's Objectives

The general aims of TerminalRISK were that it should be -

- 'highly flexible, worked at a pace and depth set by the learner'

- 'an extremely cost effective alternative to a one or two day traditional course'

- 'a thoroughly entertaining and educational approach to training'

(taken from a list of benefits of TerminalRISK from a Price Waterhouse Publicity leaflet)

Another Price Waterhouse publicity flyer lists TerminalRISK's objectives for the user :

After working through the programme you should:

- carry a mental model of the main elements of a typical CIS (Computerised Information System)
- know the “Seven CIS Risks” and how they can result in mis-statement of financial statements
- be able to identify risks and controls
- know why PW prefers to audit through, not round, the computer in certain circumstances
- have sufficient grasp of CIS concepts to be able to hold fruitful discussions with CIS Audit specialists.

These objectives were used as the basis of the evaluation.

3.2.4. Methodological Approach

Since this research is an evaluation of the existing use of TerminalRISK in Price Waterhouse, it was not possible or appropriate to disturb the existing arrangements in the training centre. Consequently the research was set up largely as an observational study of the existing use of the interactive video disk. The program itself demands a full day when used properly, but time was allowed for a short pre and post test and an interview. The pre and post test was based on the program’s teaching objectives that were set out by Price Waterhouse, and were designed so that there might be some measure of the program’s success in that respect.

Price Waterhouse prefers their trainee auditors to work on TerminalRISK in pairs, though if by chance an odd number of learners arrived it was possible for there to be a group of three or one person might work on their own. It was also important for the observational studies that pairs of learners were observed, since by noting their conversations as they worked it was possible to tell much about how they were approaching the task. This type of observation is less obtrusive than asking a single user to vocalise their thoughts which would have been especially tiring for the user given the length of time that they had to work with the program.

The interview questions were based on previously observed areas with which the learners had problems and were also designed to assess the learners’ attitude to this type of learning experience with particular attention to the video sections.

A questionnaire (appendix A) was developed based on the interesting aspects of learners’ answers to both the pre / post test and the interviews.

3.2.5. Data Collection

Research data for this chapter was collected in the form of interviews, questionnaires and observation.

Pairs of users were observed working with TerminalRISK at Price Waterhouse's London training centre. The users were selected simply on the basis that they sat at a particular work station, chosen before they had arrived. Five pairs were observed in total. After a two minute pre test (fig 3.1), they started the day's work.

Users were observed throughout the whole time they worked with TerminalRISK. Timed notes were taken on the users' interaction with the program and the video, their comments about TerminalRISK, and their discussions revolving around completion of the work. After they had finished, a post test was administered and an interview given.

Oral Pre and Post test Questions.

Pre Test Questions.

- 1 Name the seven CIS risks.
- 2 Describe an approach to identifying CIS risks.
- 3 What do you understand by the term 'access risk'?
- 4 What knowledge of computer systems do you have?

Post Test Questions

- 1 Name the seven CIS risks.
- 2 Describe an approach to identifying CIS risks.
- 3 What do you understand by the term 'access risk'?

fig 3.1 Oral Pre and Post Test Questions

The interview and the pre and post tests were recorded on audio tape and then transcribed later. The pre test was designed to establish what background the user already had in computing and what knowledge they had of risk evaluation. The post test involved the same questions as the pre test to establish any increase in understanding. The interview, lasting approximately 5 minutes, aimed to gauge the users' reaction to TerminalRISK.

A short questionnaire (appendix A) consisting of a few free response questions and four multiple choice questions was produced based on the type of questions that worked best in the pre/post tests and interview. The questions aimed to determine any qualitative change in comprehension of risk evaluation and to establish users' perception of the use of video in TerminalRISK. The questionnaires were distributed to all users of TerminalRISK at Price Waterhouse's London Training centre for a month.

All subjects were Price Waterhouse auditors normally in their second or third year of Price Waterhouse's training schedule.

3.2.6. Types of User Approach

From observation it was apparent that different users began with different expectations of the day:

'I am expected / obliged to do this, so let's get it done.'

'The day should be useful, I'll see what I can get out of it.'

'It is an easy day away from work, playing on the computer and I should get home early.'

Learners also arrived with different expectations of what technology based training is about. There were two quite different expectations. The first gave an active role to the computer, and a more passive role to the learner:

1) The computer is used to teach the learner to simply read what's on screen and all that is necessary is to answer the questions it asks.

These people feel that the computer ought to do all the work and that they are there to be taught. The second group expected the learner to be more active:

2) The computer is a tool; it is there to help and guide the learning.

These learners realise that it is they who do the work, and so are more prepared to do it. The first group were often shocked by how much work TerminalRISK requires the user to do.

If you went through it just as a logic exercise then it would be [*cheating to take suggested answers during flowcharting*]. But, if you use the explanations as to why, then it's teaching you at the same time. (Peter)

A comment from one of the interviewees revealed the importance of user attitude:

Yeah, got frustrated because it took us quite a long time and we thought, everyone else who had done it obviously just skimmed through it, oh yeah, it's an easy day, it's an easy day, finished by three o'clock and I think when we got to lunch time had hardly really got into it. You just got a bit frustrated. That was just perceptions I suppose, but it was quite difficult I thought. (Karen)

It is important to establish the users' approach to the task in a study such as this in order that the software can be designed to counteract negative approaches while encouraging positive ones.

3.3. Interface Design

To understand how well the interface design works for this disc, we consider in detail the way the users are supported in their work on flowcharting.

Introductory sequences	20 mins
Stage 1 - Overview	60 mins
Tutorial, Tasks, Bytes, Report	
Stage 2 - Data Flows	40 mins
Tutorial, Tasks, Bytes, Report	
Stage 3 - Application Risks	40 mins
Tutorial, Tasks, Bytes, Report	
Stage 4 - Application Controls	80 mins
Tutorial, Tasks, Bytes, Report	
Stage 5 - General Controls	70 mins
Tutorial, Tasks, Bytes, Report	
Finale sequence	10 mins

Fig 3.2: Structure of the disk showing approximate working times for each section

3.3.1. Description of the Use of Flowcharting

In three of the stages, the task section consists of working with flowcharts on the computer. The first set of flowcharting tasks (in the second stage) involves constructing system flowcharts by examining data flow between and within activities, as well as examining the maintenance of ‘standing data’. The third stage tasks concern identifying points at which risks might arise and marking these on the flowchart. In the fourth stage the user must try and cross off potential risks by finding controls for them.

The Tutorial prior to the Task section details the theory behind what the trainees must look for, but does not give any specific information about Portland’s Computerised Information System (CIS). So the users are to complete these tasks by browsing through the file of printed material for the relevant information.

Input into the flowchart in stage two takes the form of multiple choice entries. First the users select which activity they want to work with. An ‘empty’ flowchart is then displayed as a

series of connected flowchart boxes without any detail of processes. The user must move between processes choosing the appropriate answer from a long list of possibilities. For example, for each flowchart process box he must choose which (if any) files are referenced or updated, what reports or documents are produced, what input there is, and what data is transferred between activities.

The screen is split in two for working with the flowchart. The top half displays the process box that the user is working with, or the computer's response when the user gets a section wrong. The bottom half displays the list of possible options, each with a box beside it which can be checked and unchecked.

Working with the flowcharts is simpler during stages three and four. In stage three, the user goes through each flowchart four times, each time placing a different symbol on the points of the flowchart where unreliable data could arise. For example, the user places a padlock symbol on each spot where they think an access risk might lurk. In stage four, the user goes through each flowchart again, this time looking in the case study file for controls for each potential risk, and on finding them crosses them off the flowchart. Any potential risk at the end that is not crossed is an actual risk.

3.3.2. Working with the Flowchart Program

The user of *TerminalRISK* works with the flowchart for a good percentage of the day. Flowcharting is of central importance to working with *TerminalRISK*. Therefore it is important to see how the users find working with it and to see what their experience can tell us about the effectiveness of the interface design. From the final interviews we can see that learners appreciate the value of flowcharting.

Peter: I think you started on quite a high and then, stage two, I thought, was quite long and laborious.

Clive: Yeah, I mean, the flowchart and graphs.

Peter: No, I wouldn't say it's less helpful because at least there it's illustrated clearly for you, if you miss out controls, all you do is whizz back to the flowchart and if there's not one crossed off, or if it's been crossed off where it shouldn't have been, it's easy to find. Rather than, I mean, you can imagine wading through the text as indeed it shows you how to do. You wade through the text and you can miss things left, right and centre whereas if you put it in a diagram, literally you just check its little points off...

John: Well the flowcharting was good I thought.

Brian: Yeah.

John: Once you got the hang of it, it was a bit tricky at the beginning... I don't know actually. I think doing the flowcharts is quite useful, when we did all this theory of the CIS for P1 which are the exams we did in November, looking at those flowcharts, I just turned over every time I

saw them. But doing it on the screen is actually quite, you know, that old thing about doing is better than seeing.

The comments above are from interviews taken after they had completed the programme. While most users recognise the importance of flowcharting, many of them, especially at first, found the flowcharting difficult. There are several reasons for this.

1. Unfamiliarity with flowcharts and flowchart symbols

Many of the users were unsure what the flowchart symbols meant. One user commented-

What is that symbol, I've never seen that one before. (Simon)

Another, after having repeatedly failed to find the solution to a task section, said

Maybe we don't understand the symbol. (Clive)

I don't think the flowcharting was very well explained. I think it would have been quite a good idea to explain. I think it may have been actually because we're supposed to know what the symbols look like. (Brian)

The symbols were defined during the tutorial section and users did have an idea of what the symbols were, but were not confident. It would be useful if there was an easy way for the user to check the meaning of the symbols via a look-up chart available at any time from a menubar.

2. Uncertainty of how to work flowchart program

Most users found that it was unclear how to work the flowcharting section. The normal approach is to experiment by clicking on different boxes and to see what happens. This approach seems to work, but is not beneficial to the confidence of the learners because they are never certain that they are taking the correct approach. It is also time consuming and alienates and distracts the user from the purpose of the programme. The click and see approach is at its worst when the user has in fact missed clicking on the box or has not clicked the mouse button properly and so nothing happens: the user then assumes this was not what they were meant to do and so discards this option.

Some of the confusion about what to do is repeated on the flowcharting in stages three and four. The learner is again unsure what he has to click on or point to, though this is usually resolved.

On the second flowcharting task, in stage two, some of the multiple choice options are highlighted in blue, while others are black as before. The blue highlights show which options the process being charted uses as a whole. The user must decide which options the sub process at this stage uses; these options may, or may not be highlighted. Many users did not realise straight away (if at all) the significance of the blue highlights, some believed that it was some kind of guide to which ones to click.

John: I think these are the options that we are supposed to put.

Brian: I think it's realised that we are so slow.

Karen: What's the point of this.

Simon: This is weird, we're just following the blue dots

Karen: Follow the yellow brick road.

A context sensitive help option might be a solution in cases such as this where iconography appears to fail.

All the users tried to change their selections while the explanations of why a choice was wrong were being displayed on the screen with the multiple choice options still being displayed beneath. But they were not able to change their answer until all the explanations had been read and they selected 'try again'. Being able to change the selections while the explanation is still on screen would be a useful option.

Another point at which a significant portion of users were confused was that only the process box that they were working on was displayed on the screen: the rest of the flowchart was off screen. After completing all of the details for this process box they thought that they had finished and were surprised to see a warning that the flowchart was not completed as they put it away. This caused confusion, but again with experimenting they soon found the problem.

While selecting options in stage two, one of which is 'No data flow', several of the observed groups, having decided that this is what they wanted, selected it without first de-selecting options that had previously been selected. The problem here is a logical one : it is possible to have 'No data flow' selected as well as having data selected. This is a small point that is soon solved, but one that most users come up against.

The problems in understanding the flowchart program interface are overcome as the learners become more familiar with the way it works during the day. However, these problems diminish the users' confidence and detract from the learning process.

3. Too many options in multiple choice

The flowcharting tasks in stage two involve selecting the correct data from a list of between five and twenty items. Between one and five items have to be selected at each arm of the process box on the flowchart. This has to be done for each process box of each flowchart, which adds up to quite a substantial number of choices, and helps explain why stage two takes so long.

Getting the correct combination and number of items is a complex operation. To do this by chance or trial and error is time consuming and frustrating to the learner. In fact if a pair of users were given 15 options and between one and five of them were correct they would have to

find one of the 4943 different combinations to get the correct solution. Unless care and attention is spent working out the correct answer from the user material, or studying carefully the explanations, once one attempt has failed the user may waste time trying different combinations.

Interviewer: Which areas did you draw from to complete the data flowchart?

Mike: Suggested solution. Basically just trial and error, - you've got so many options there.

Thom: It doesn't offer you what's involved, chopping and changing. After which you just get disheartened because the thing keeps telling you your solution isn't..... er...

Interviewer: Do you think that the computer helped?

Mike: I think the information's probably there, if you're going to dig for it.

The program should give more support on locating the correct combination, perhaps by encouraging learners to attempt to work out the correct response, and by providing feedback to incorrect answers which helps to correct their next attempt.

If the learners did not simply guess at the options, they had to consider why each of the options was (or was not) to be included. Since only a few of the options were correct, the user would have to consider the validity of more incorrect options than correct ones.

4. Explanations of wrong choices too terse

When users get a flowchart section wrong they are given the option to have an explanation of why it is wrong. All groups used these explanations extensively. The explanations indicate which selections are wrong, and also indicate which selections they should have chosen and did not. After an explanation it ought to be possible for the user to correct their response. From observation it is usual for users to make one or more further attempts at the solution, examining the explanations again, before they get the correct response. Sometimes even after reading the explanation and retrying the task, the user takes the suggested solution. Rarely does the user choose the suggested solution straight after reading the explanations - it is much more rewarding to get the question correct, even with the help of the explanations, than to take the suggested solution.

If it is possible to find the correct solution to the task section simply by examining the explanations then why do so many users still need several attempts after they have read the explanations?

One reason is that the user cannot remember what the explanation said. As discussed above users are not able to alter their answer while the explanation is on screen. All observed users would have found this beneficial. Most learners endeavoured to copy some of the explanations down because simply remembering the explanations is difficult, especially as

often there is quite a long list of them. Many groups tried this and soon gave up as it was such a lengthy process. One pair even discussed how useful it would be if the explanations could be printed out. Some way to refer back to the explanations would help learners complete the flowcharting tasks.

Users found that while the explanations indicated which options they should have picked they were too brief to clarify the reasons for selecting these options. As a learner observed in an interview:

And it didn't really explain the answers that well, so you couldn't, took you a long time to get it all correct. (Karen)

Another user commented during observation:

It [*the explanations*] really doesn't give you a lot of help, if you get it wrong it tells you you're wrong, and says the same message each time you get it wrong. (Simon)

It should be noted that learners should not be relying on explanations in order to complete the tasks. Although this might make the tasks easier, it could be counterproductive since they are expected to be able to find the correct answers for themselves by working through the case study file, in the same way as they would in real life.

5. User mistakes are disheartening and lower confidence

From observation it was clear that users appreciated getting the tasks correct. Even after many failed attempts, once they got something right they got noticeably brighter, often making good comments too.

Conversely, users soon got very frustrated during a series of incorrect attempts at a task, and this frustration often lead to swearing and loss of confidence. Users were not worried about getting task sections wrong. It is getting them wrong repeatedly that was the problem. As discussed earlier, even after reading the explanations, the learner frequently went on to get the task wrong again.

Users must either complete the task correctly or use the suggested solution option before they can go on. Users are not content to take suggested solutions since there is no benefit in doing so, and would much rather get the question correct themselves. Users are quite happy to use the explanations to help them complete the tasks. If the users were given even more help from the computer when getting a section wrong repeatedly, they would be able to complete the tasks themselves, and should better understand how to arrive at the correct solution, so relieving the cause of frustration. The users would be happier if the explanations helped them understand what they should have done, and so increased their understanding.

6. Users make slow progress in the flowchart section

Many users were concerned that they were not making enough progress. This feeling was especially strong when the users finished the tasks on stage one or stage two, and they returned to the main menu to see how little had been marked off as done. The first two stages took the users up to lunch time - or longer in some of the observations.

Stage two was a particular problem. Although the user material lists stage two as taking approximately 40 minutes, the observed pairs took an average of 105 minutes on this stage. The shortest period that any of the observed groups spent on this stage was 65 minutes. While working with the flowcharts on stage two, many of the users realised that they were taking more time than they should, and so tried to work faster. This rushing normally led to more guessing of answers (which given the number of possible combinations, is futile) and more suggested solutions.

All observed pairs also took longer than the stated approximate time for stage one. However for stages three to five they spent less time than listed in the guidance notes.

It was common for users to compare their progress against other users in the room working at different workstations. Slower pairs felt that maybe they were not tackling the tasks as they should, or had missed out on some information that speeded things up. When asked, faster groups admitted using suggested solutions to speed things up.

Simon: I thought it was quite difficult. I felt slightly frustrated at times when I felt that we seemed to be making a lot of mistakes, not quite sure where, especially when we were putting in areas of the flowchart, there were certain areas you just felt you weren't really getting very far.

Clive: I thought we were not very fast, it doesn't explain very well that there was a short cut there.

Peter: Yeah.

Clive: And I was a bit frustrated seeing everybody doing everything so quickly.

Peter: Yeah.

Clive: When actually they were just doing the suggested solution.

Peter: Yeah.

Clive: And we were trying to do everything ourselves.

When users are in control of the pace of the learning process, especially when working for long periods on the same section, they need to know that their progress is satisfactory.

3.3.3. Summary of Findings on Interface Design

Regardless of the problems above, learners appreciated the importance of flowchart construction, many of them seemingly unconcerned that they had not understood all the

details, but content in the knowledge of what it involves. From the above discussion we can extrapolate to the following general recommendations that would improve the interface design for this or any other interactive teaching program:

- (a) A method for checking the meaning of any special words or symbols.
- (b) A context sensitive help option, to give specific help on operating the program when visual features fail to be interpreted correctly.
- (c) Hide any options that have been disabled to avoid the expectation that they are active
- (d) Remedial help when users consistently fail to get the correct solution.
- (e) Avoid repeated incorrect answers by offering sufficient guidance, rather than giving the correct answer too soon.
- (f) An indication of how long learners should be taking on the each section or stage of the program.

3.4. Educational Role of the Video

The focus of this thesis is the role of video in multimedia systems, so part of the evaluation, especially the observation, was used to investigate how the video contributed to the users' learning experience. This section begins with a description of the video and then documents the evaluation findings.

3.4.1. Description of the Use of Video

The Plot

A computer auditor (Marilyn) has discovered suspicious activity while investigating Portland's Systems CIS. Her enquiries have led her to the Motel owned by a programmer Norman Bytes, an ex-employee of Portland. Marilyn goes missing after a 'Psycho style' shower scene. The computer manager from Portland and Marilyn's twin sister (Ben and Laura) are worried about Marilyn. In an attempt to discover what led to her disappearance, they start to analyse Portland's CIS themselves to see what she might have found. Meanwhile Norman Bytes is hacking into the system to see how he could best revenge his dismissal from Portland.

Tutorial and Bytes

Ben and Laura must work through a five stage approach to identifying computerised system risks to discover Marilyn's fate. It is this process that users of TerminalRISK follow in order

to gain an understanding of risk auditing. Since Laura has no knowledge of risk assessment, Ben describes the process. It is this description, accompanied by computer graphic sequences, that forms the tutorial sections that the user watches at the beginning of each of the five stages. After watching the tutorial, the user practises the process for the stage which the tutorial described, by completing a computerised exercise.

After completing the exercise the learners watch the 'Bytes' video section. Norman Bytes is following the same five stage approach as Ben and Laura. He is also trying to find weaknesses in Portland's CIS - so that he might exploit them. In this section Norman explains how he might turn a weakness in the system into a catastrophe.

The "Psycho" Device.

The video sections form a narrative which unfolds during the day. The narrative structure is very straightforward. Events are portrayed in temporal order. The action is on one level with no implied meanings. The users are given a privileged point of view since they see the action of Norman Bytes and Ben and Laura. Its main device is its reference to Hitchcock's 'Psycho'.

One of the purposes of video in TerminalRISK is to provide an incentive to complete the tasks so that the learner may discover what has happened to Marilyn and may see the villain caught. For this incentive to work a certain amount of tension and curiosity must be aroused. The video taken on its own does go some way to producing this tension - showing hidden cameras, a figure creeping up to Marilyn showering and Ben and Laura's concern. The main tension, though, comes from the references to 'Psycho'. From this the learner knows that Norman is a deranged killer, that his mother is not real, and that Marilyn is probably already dead. The learner will have a complete blueprint for interpreting Norman Bytes based on Norman Bates.

The knowledge of 'Psycho' that the learner has is important in interpreting the video as intended. People who have not seen the film may wonder about Norman's strange relationship with his mother, and miss the full meaning of the shower scene. This does not leave them confused since experienced 'readers' are quick to find an interpretation of a text. They will still recognise Norman as being unstable, and realise the sinister nature of the shower scene (in fact, it is hard to imagine someone from western culture who is not aware of the Psycho shower in one form or another). They will draw solely on the common experiences of life from which the original Psycho drew, though they will not pick up details such as the similarities of name between Norman Bytes and Psycho's Norman Bates. The ability of a text to survive different interpretations is a necessary part of all film and television production, and in fact is important if a text is to be used by people of different backgrounds.

The user who has seen *Psycho* has his knowledge used against him at one point. He has been led to expect that Marilyn has been killed in the shower: Norman Bates killed all of his victims. But this expectation is thwarted at the end. It is the manipulation of expectations like this, and the multitude of possible events and meanings that produce interest, draw people into the 'story' and stop a production becoming predictable and boring.

3.4.2. Evaluation of the Role of Video in *TerminalRISK*

While looking at the role of video I shall only be examining in detail the video in the Tutorial and Bytes sections and not the computer graphic sequences. The video in *TerminalRISK* has three functions: (a) to order and support the programme, (b) to entertain and motivate, and (c) to aid instruction.

Order and Support

Rather than just teaching facts about risk assessment, different strategies are employed to make the course more acceptable and less didactic. The foremost device is using a case study, so that what is being analysed could be a real life situation. Also the narrative works as a device to give the approach more of a temporal attribute. The narrative requires that each stage be completed one after the other. The video sequences show Laura as having grasped the last stage then realising or being shown that the next stage logically follows on. On a lower level, devices are used to present information. Ben, as operations manager, understands the five stages of risk assessment, but Laura does not, so while Ben is describing the process to Laura we are also being told. Ben's character responds to Laura's question about what they should do next with "here let me show you", and he presses a button on their computer terminal, at which point the user is shown graphically the explanation accompanied by narration. A similar ploy is used in the 'Bytes' section. Norman, trying to get his mother's approval, describes to her, himself and us, what he is doing and why. In doing so it helps the user to place individual operations in a logical narrative sequence.

Interviewer: What do you think are the benefits of remembering the video or the narrative?

Simon: Well, I, there was a certain, there was a, a very much sort of top down approach. There was a very, I think I remember the sort of logic of how they went through it. They started off with a very broad view and narrowed it down to a certain area then focused down again and looked inside that area and generally worked their way down to the basic controls and to find the basic weaknesses and I thought it was good they sort of put it into a kind of perspective which you sometimes don't see if you don't go all the way through something like that. Was quite interesting seeing that happen. But, I wasn't making a very good job of doing it myself.

The Bytes section had a specific role in supporting the tasks. Users are expected to watch the Bytes video after they have completed the tasks for that stage. Each task has brought the

user a step closer to identifying problems in Portland's CIS. Having done the task, users are perhaps unclear of the significance of what they have found. The graphical sequences during Norman's section explain how the risks can arise and how they may be exploited. The value of the graphics part could account for users' perceived value of the Bytes sections, as a whole, and this value is then conferred on the video as well.

In learning a system of some detail and complexity, it appears to help the learner if they can be given a main thread by which to organise the detail.

Entertainment and Motivation

By far the most important purpose of the video and narrative as perceived by the users, was to maintain interest. Typical views of the users when asked what purpose the video served were:

Primarily what I'd say, is to keep you interested. I mean can you imagine sitting through doing exercises like that on the computer for the whole day without a story-line? (Peter)

Adds a bit of spice, it's pretty dull otherwise. I think if you just work through the computer parts, it would be pretty uninteresting, wouldn't it? (John)

The link between interest and motivation is clear from the statements above. The narrative makes the course more interesting and in turn this interest enables the learner to keep going.

The interview data is further corroborated from the questionnaire. Around 85% of respondents particularly agreed that the video "makes the programme more interesting". And when asked about narrative nearly all agreed that "it made the programme more enjoyable to be working towards solving a problem, rather than just learning the principles".

There are three reasons why video/narrative makes the course more acceptable.

Firstly, the video in TerminalRisk provides links to the 'real world'. It would have been possible to teach risk assessment on an academic basis by simply giving instructions on how to locate risks, documented examples of actual risks or case studies of real situations, but such descriptions would probably appear impersonal and cold. The Norman Bytes story, while being fictional, (in fact highly improbable) gives the users a situation and characters that they can understand, bringing the whole subject down to a level of people and events rather than facts and examples.

I started to get quite frustrated at one stage, but I felt that it certainly keeps things going when you've got a bit of a story-line going and you're sort of following through a process and you're seeing what's happening and you're seeing somebody else on screen doing the same thing as you are. (Simon)

The narrative would have worked at least as well if a real case had been acted out in a similar manner, but this would have been a security risk in itself.

Secondly, switching between the variety of media aids overall concentration. Different media present information in different ways and working with them requires different approaches. As two users observed when interviewed:

Well, I'm quite impressed. This is my first one, first time to do an interactive video course, you can actually sort of spend the whole day there doing it on your own. It's much more interesting. For example, what I was doing yesterday, I was doing some Lotus teach yourself Lotus and there's variety there between the computer generated graphics, the text, you know, the video, I like it, it's pretty good, it's the future. (Clive)

Well whenever you have something explained it's always done in terms of an analogy, in terms of a story. It doesn't matter whether you talk about the risk of someone tapping in, all that this is doing, it's putting it in context and it's a change in the nature of the way it's taught. It's just like when you are in a lecture, sometimes you read a bit of the book sometimes you listen and sometimes you write things down, it's the same thing isn't it, just getting a bit of variety. (Brian)

The third reason suggested for the value of video is that it allows the viewer to relax. This is not to suggest that viewers of video and television are inactive - far from it. The activity is not one of intense concentration or note taking, but one of observation and decoding the narrative. These are the activities that we perform all the time; we are always making sense of and adjusting the narratives that happen all around us.

Observation showed that when the users came to a video section they sat back, put their pens down and relaxed, sometimes even with a sigh.

Many users found the Bytes sections more interesting and enjoyable than the tutorial sections:

John: ...that bit [*the bytes section*] was much more interesting than the Ben and Laura bit, in that he was explaining how he was going to try and get in. I mean the boring part was the bit that we did, which is looking for ways that people might conceivably get in. Sort of defending from the inside, so to speak. It's much more interesting seeing him trying to get in.

Brian: Yeah cause they were trying to analyse the system. He was actually telling you the bits that you wanted to find. It was a bit of a guide really.

John: The Bytes bit was most informative, in terms of what you were picking up in the shortest period of time, that was it.

Peter: Um, I've seen Norman's stuff where it's more sort of giving you food for thought rather than explaining things. Is that the right way round?

Clive: I think, they're into like putting into practice what you know, what the other guy was getting worried about. You know for example, finding those fifty pound, fifty dollar, sort of like minimum amount, then showing how Norman was utilising that.

Mike: ...I think they should have made a bit more on the Norman Bytes and his mother, that was a bit more interesting.

What makes this section more enjoyable than the tutorial sections? Drawing on techniques of film analysis we could consider two possible reasons for users' preference for the Bytes sections.

1) The Bytes approach appeals more to the way people think.

Ben and Laura are in a defensive position: their task is to examine the whole system and to try to locate all weak areas. Norman has the single minded objective of attacking the system: he must find any weakness and do as much damage as possible. Ben and Laura's aim is more diffuse and less tangible than Norman's and so is less satisfying.

Ben and Laura's approach is, of course, the correct approach, if all risks are to be systematically discovered.

2) The Bytes character is stronger.

Norman is a much stronger character, mainly due to the references to Psycho. From this and Norman's portrayal in TerminalRISK the user already knows a lot about this character. His schizophrenic personality makes him more interesting. He is portrayed in TerminalRISK as a stronger more determined man, almost larger than life. Psycho's Norman Bates however was a pitiful and nervous person. In comparison Ben and Laura's characters were weaker.

Norman's glee at finding weaknesses in Portland's Systems CIS was another factor to add to the enjoyment of this narrative. Ben and Laura were more dignified when they were discovering the problems.

Video presents a very different type of learning, and is better suited for some situations than others. Video is good at constructing narratives, and this is what it is used for in TerminalRISK.

To aid instruction

The goals of the narrative simply lie in discovering what has happened to Marilyn and catching Norman Bytes. Risk assessment of Portland's CIS is the route to fulfilment of this objective. It is understanding this assessment that is the objective of TerminalRISK.

The video does not present any information that the users need to remember to be able to complete any of the tasks, nor any direct information to help them understand risk evaluation.

The video therefore is not just didactic. Instead, its narrative quality appears to help in assimilating and understanding the course. Over three quarters of users agreed with the statement on the questionnaire: "Remembering the story will help you remember the risks and

the approach to identifying them.". Users did remember risks, as shown by the post test data, although this is also attributable to sections other than the video.

3.4.3. Summary of Video's Role in TerminalRISK

From the above discussion it appears that video in TerminalRISK served a number of functions which can be generalised as follows:

- The narrative helps order the sections giving an easily understood thread on which the more complex ideas of the program can be hung.
- Typical televisual devices can be used to link the sections together.
- The video sections provided extra interest and so aided the learners' motivation. It did this in three ways - by providing links to the real world, switching between the media, and allowing time for reflection and consolidation.
- Remembering the narrative may help the learners to remember the sequence and detail of a complex system.

3.5. Learning Gains

The value of the TerminalRISK disc must be judged in terms of how well it achieves its objectives and improves users' understanding of CIS risks. The evaluation used both qualitative and quantitative methods to assess this.

3.5.1. Quantitative Gains

Analysis of the questionnaire's pre and post tests reveals learning gains attributable to TerminalRISK. Of fifteen questionnaires completed, eleven learners attempted to name risks while four did not name any. The quantitative analysis is taken from these.

Nine people identified the two types of risk (general and application) in the post-test, compared with none in the pre-test. Learners named risks from both categories in the pre-test, but did not differentiate between categories.

In the pre-test learners identified, on average, 1.27 of the three general risks, that is 43% of them, and 1.09 of the four application risks, that is 27% of them.

Learning gain between Pre and Post Tests.

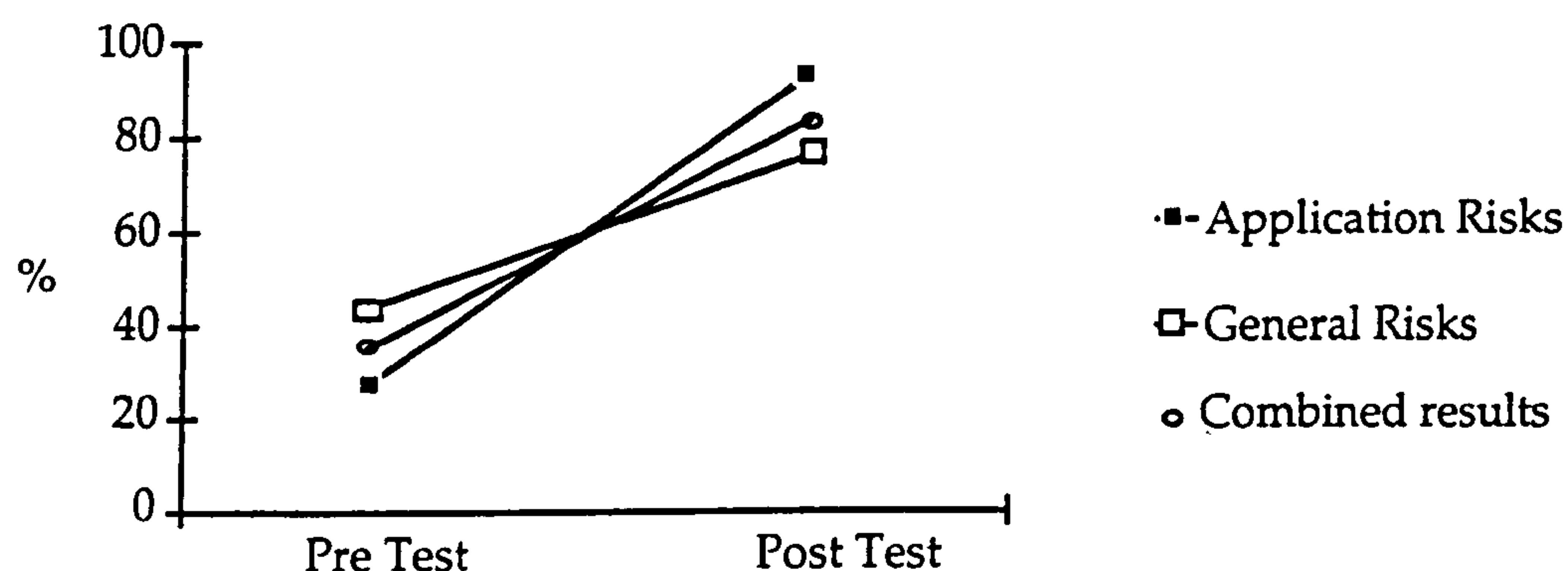


fig 3.3 Learning Gains

The post-test results were clearly improved. Users listed an average of 77% of the general risks and 95% of the application risks. Of the eleven learners, seven of them listed all seven risks in the post-test.

The program succeeded in significantly improving users' knowledge of the risks, but did not achieve 100% success with one third of the learners.

3.5.2. Qualitative Gains

All users showed qualitative gains in their questionnaire answers. Their post-test answers were demonstrably clearer and better structured, drawing on material that they had been working with during the day.

The general structuring of the post-test answers more closely matches that of TerminalRISK. A typical example of this is splitting the two types of risks into sections and listing risks as points with an explanation under each section (see appendix B). Some learners also listed the five point approach in the post-test, reflecting fairly accurately the five point approach of TerminalRISK. Some learners reflected the theme which was used between stages of TerminalRISK of 'turning up' the power of a microscope to examine a program area in greater depth.

A five step approach will gradually focus in on the particular area of concern (Marcus)

Approach should be to zero in on the detail progressively. (Clive)

Post-test answers were also better structured, information being broken into points, and subsections being used.

Different learners suggested different possible risks and various solutions (often incorrect) in their pre-tests. These descriptions of risks and suggestions on how they might be combated

were often mixed together. In the post-test answers there was a much clearer separation of risks and solutions. There are three possible explanations for this. (a) There is not necessarily an approach to identifying each risk, but an approach for identifying them all. (b) In *TerminalRISK* the risks are explained in a different section from where they are identified. (c) The clearer structure is because learners have a clearer understanding of the relationship between risk and risk finding.

Many of the pre-test answers listed points that were not in the scope of *TerminalRISK* or were erroneous, such as talk about hash totals and check digits. This type of answer was generally not apparent in the post-test.

It is quite clear from examining pre-test responses that people initially have a clearer understanding of general / physical risks. This is shown in the quantitative data, where the pre-test users, on average, identified 43% of the general risks and only 27% of application risks. It is easier for learners to envisage this sort of risk rather than the more abstract application risks. This situation is reversed in the post-test as learners recall a higher percentage of application risks than general risks. This is probably because *TerminalRISK* spends more time identifying application risks.

Some users demonstrated a degree of uncertainty or wariness towards the CIS in their pre-tests, with comments such as:

Can't actually see what's going on. Can be very daunting. Small errors may easily expand into very large problems. (Edward)

CIS risks concern the danger that the increased level of computerisation will so distance the user from the logic of the system then errors will be made which can not be foreseen, or adequately traced when the problems are found. (Don)

Don's post-test answers, like other learners, showed a clearer layout and a logical approach to identifying CIS risks that should have helped ease his apprehension of CIS.

In summary it is clear that the students made significant learning gains. Even though the programme took them through a full step by step approach to risk auditing, it was not one of the objectives of *TerminalRISK* that the trainee auditors should be able to carry out such an audit on the basis of just using this programme. Instead it was important that the users had a general and usable understanding of CIS and potential risks.

3.6. The Experience of Learning from Interactive Video

Although the bulk of this chapter is centred on the video and flowchart sections, this section will deal briefly with points that were particularly noted during interviews and observations.

All observed users had problems with the mouse to some degree. There were two difficulties here. The first was unfamiliarity with the use of the mouse. This would have been quickly overcome were it not for the second problem - faulty mice. The pointer on the screen did not move smoothly with the movement of the mouse, and often would jump erratically making pointing at a selection sometimes quite a task. This led users to think that they had clicked a section, when in fact they had missed it. This was a particular problem when users were not sure if they were doing the correct thing.

Only one observed pair found the organiser (an aid to understanding Marilyn's printed notes), although all of them looked for it. Two pairs decided that the correspondence in Marilyn's file was what was being referred to.

Users admitted finding that reading from the screen was tiring if the section was long and not broken into short paragraphs.

I got a bit bored of reading reports from the screen which is, there ended up being lots of material, reading stuff from the screen is very tiring and it's much better where it's short chunks with prompts than a big screen of information, cause it's much easier to read a small chunk and assimilate it, than it is to read a screen. And a prompt to turn the pages gives, you know, you get a natural break and you take it in better and I think that the um, I was getting a bit bored with the long, especially that last one, that last one was quite long. (Brian)

Many learners found the suggested times hard to keep to. All observed users exceeded the suggested times on the first two stages and consequently rushed the other stages. Generally users commented that there was too much to be covered in the allotted time, but it was noted of the five observed pairs that only one pair did not leave before 4:15pm. The pair who stayed until 5:30pm commented:

Simon: I think it needs to be shorter. I think there's too much there to absorb. I mean I'm not particularly good with CIS but I just felt that there was an awful lot to do and I didn't really have time to get to grips with the real understanding of it.

Not many users tried the 'help' function. Those who did did not find it particularly useful. A more accessible context-sensitive 'help' would be better.

Motivation was a major factor in determining progress. Some learners had stronger self-motivation. One group needed little encouragement, and were in fact often working ahead of the program, examining all information in sufficient detail. Some of the other pairs were more poorly motivated and would have benefited from more encouragement / help especially during the tasks. One poorly motivated group observed:

Carl: I was definitely more tired after lunch. That was facetious! I would say that the video bits I was still interested in. I was equally interested in them throughout 'cause I hadn't read those. I like pictures. You find that easy to learn, those bits. The little exercises became tedious because . . .

there were just too many too many of them. There were too many, too close together. Is that all in the risks section?

Vince: Yeah all really repetitive.

Carl: Yeah. Too repetitive so I lost interest very quickly. There perhaps wasn't enough motivation to get it right. ...We liked betting over whether we were going to get it right or not.

Vince: I owe you two quid as well.

I: Is there anything else?

Vince: I was going to say there could be gambling formally built in to the programme.

Carl: I thought you weren't sufficiently encouraged to get it right. You could build in a bit, sort of, how many times you got it right.

In general, then, designers of IV should be aware of how the complete learning session is experienced by the learner. It can be seen as tedious if there is too much reading from the screen, if there is too much to cover in the time available or if encouragement and interest is not maintained throughout.

3.7. Summary of Findings on TerminalRISK

This chapter may seem negative in its study of flowcharting and analytical in its study of video, but that is not an indication that TerminalRISK is not effective or well received by the learners. In fact many users were quite enthusiastic about this type of training programme, while still having some reservations about certain aspects of the implementation of TerminalRISK.

Yes, the problems that we had with it were with the format rather than the technical aspects of it. (John)

I think it's good how you remember the video as well, um, I think it's quite good. I think I'd have to go away and read through some of the stuff. I wanted, I mean I've not got time to do my DPPA just now. I've got notes and I'll hopefully get a chance to do that tomorrow morning in the office and I think I might learn more just going away by doing that.
(Karen)

All observed users came up against similar problems, and all became frustrated to a certain degree - especially with stage two's flowcharting. The learners were able to distinguish the implementation problems from the learning goals and so were still able to work towards them. Problems working with programs, as with any form of learner material, do detract from their value, since the user spends time and cognitive effort working around these problems which would be better spent on learning. Problems such as these alienate the user from the task, as they become painfully aware of the process of learning, rather than getting wrapped up in it.

The users' self motivation is an important component for progress in TerminalRISK, as with all learning situations. As expected, the more enthusiastic learners, those who are prepared

to work harder, are the ones who get more out of TerminalRISK. All observed pairs, and questionnaire respondents showed a significant gain in both quantity and quality of post-test answers when compared against the pre-test. One interviewee observed:

It's really like being at school again where you get a lesson then you have to do questions and then you get another lesson, on something that leading, led you on to from the first. You get out of that habit when you have a job like this, you're used to having to sort of do more for yourself. This is more sort of drumming it in to you. It's like it said near the end of the thing, we'd have a job not to recognise what the problems were by now... (Peter)

The general opinion amongst users was that TerminalRISK does not give them detailed knowledge of CIS risk auditing, but instead gives them an all round grounding in the concepts involved.

Just a general approach. Now if we went out and had to do some, some work of this nature we wouldn't just sit there with a great big question mark over our heads. We'd know where to start from. It's like you said, using even just a simple bits of using your standard manuals and CIS department and of course, the general risk assessment we've done today. ...It's not like sort of some new management manager course that you have to go on to learn how to do it, full stop, every single thing. This is an introduction to it and then later on there'll be a follow up course to it. And I think this is the best way to learn. (Peter)

And in terms of understanding the answers that you'd be given to the question perhaps having an idea of what sort of questions you need to answer, it's good for that. It's not enough to be able to audit something from scratch, but it is enough to continue from what was done from the previous period. (Brian)

Video in TerminalRISK was received very well, and does seem to be effective in that it motivates the learners, keeping them interested in what could be for some people a very dry topic. The interviews and questionnaires showed that users perceived the video and narrative as helping them to remember and identify the risks and giving real life associations to the principles and risks in CIS.

Further research here could involve looking at the retention of the facts and of the processes taught by TerminalRISK after a period of time, or testing to see if learners who have completed TerminalRISK are more successful in the taught section of the course which takes place later in the year. Another interesting research area would be to examine, some weeks or months later, whether the narrative during TerminalRISK does indeed enable the users to recall the facts and processes taught.

Learners were in agreement that multimedia learning of this sort is the way ahead and that they would be happy to see more of it.

I think they're very good ways of learning. This is a general point. I've done two now, I've rated all, both of them, with the highest mark you can give, you know, a great way of learning. (Peter)

Well, I'm quite impressed. This is my first one, first time to do an interactive video course, you can actually sort of spend the whole day there doing it on your own. It's much more interesting for example what I was doing yesterday, I was doing some Lotus teach yourself Lotus and there's variety there between the computer generated graphics, the text, you know, the video I like it, it's pretty good, it's the future. (Clive)

3.8. Conclusions

The evaluation of the TerminalRISK has highlighted some points that may be generalised for the design of further multimedia teaching programs. It has also helped to specify the research problem in more detail.

3.8.1. Interface Design

The design of the interface needs to take into account the different users' learning strategies, allowing the user to identify the learning task and then to develop a strategy that is appropriate for their learning.

The designer of the system needs to identify the types of approach and determine what kinds of options should be made available to the learner to plan their work. To do this the learner will need to have a clear understanding of the task, and have knowledge of the level that they are expected to work at.

The flow charting showed a need for fuller extrinsic feedback as well as intrinsic feedback. Without feedback the learners were unable to adjust their next answer. This, as discussed in Chapter One can enable students to learn from their mistakes. The designer of the system will need to determine what is the appropriate level of feedback to promote learning and the extent to which it should be intrinsic or extrinsic.

To help plan their learning strategy, the learners needed a yardstick for both achievement and progress. This would enable them to know how much effort a section requires, and would encourage those who think they are doing badly when in fact learning is simply difficult. The more of this type of information that students have, the more able they are to make judgments and decisions about their learning.

The amount and level of user help needed to control the program was another issue raised. The interface and the task in this instance were complex, and consequently the learners found it confusing to establish what they should do at times. Context sensitive help or on screen guidance that is tailored to the sort of problems that a student may encounter could be one solution. A button marked 'help' was on screen for much of the time. Interestingly none of the students tried this, even when they were stuck. Perhaps this was because the same button

was on all the screens and users assumed that it would reveal the same information, which would be too general. This analysis also showed the need for some form of remediation when users constantly get a section incorrect.

While working with the flowchart task students were given many possible options to choose from, most of them incorrect. While it is necessary to be able to recognise what elements are present at each stage of the flow chart, it would be more useful if the system encouraged a way of working out which options are to be included (rather than working through a set of options looking for what is not included in order to see what remains). The designer of an educational system needs to decide to what extent the learners should be allowed to consider incorrect options before such an activity becomes confusing and inefficient in its use of time.

The Role of Video

The examination of video in this preliminary study has pointed out some of the possible roles of video in an interactive environment such as TerminalRISK.

The narrative in TerminalRISK did work to help impose an order and to link sections together. The video sequences in TerminalRISK did need to be viewed in the intended sequence for the narrative to make sense. Due to its structure all learners did work through TerminalRISK in the anticipated sequence and so the narrative worked. Other interactive educational programmes may give the learner opportunity, or require them to work through the programme in a different order. A conventional narrative in such a programme would require re-thinking if it was to help order the learning in the same way.

Unlike a conventional film or television narrative, the video sequences in TerminalRISK were in short sections through a whole day's learning. The user carried on the idea that a story was in progress, over the sections where the video was not running, in their own minds. This breaking of the running is not unusual for followers of narrative though, since it is what happens between sessions in reading a book, or between episodes of an ongoing television serial. Also the viewer is used to the discontinuity in time that this gives since it is normal for the narrative of a video programme to run in a different time frame; the grammar of television reducing, expanding and skipping time so that a story that takes place over days or years can be shown in an hour or so.

TerminalRISK used televisual grammar within the video sections to build a narrative as normal, but also used similar devices to link to other sections, such as the animated sequence. The narrative was also carried over in a way not possible before in television by involving the learner in the story by way of them becoming an investigator who is trying to find Marilyn too. Whether televisual devices can always work in the same way in multimedia as they do in television needs more investigation.

Video's ability to add interest and motivation by adding a 'real life' dimension to learning was also evident in *TerminalRISK*. In this case it was by way of portraying a 'real' person breaking in to the CIS, rather than just describing the potential risks. This is another example of how an existing use of video can usefully be carried over into a CAL environment in multimedia. In addition to the existing abilities of video there was evidence that the user benefited from switching between different media and gaining a different perspective on the same issues. The video sections also gave the learners a chance to relax a little, by punctuating the learning with more easily accessible video. These sections indicate the end of one section and the beginning of another and allow the user time for reflection and consolidation of the previous section and to prepare themselves for the next part.

These different functions of video, while in part based on existing uses of video, are new and may form some of the basis of grammar of multimedia.

This preliminary study has hinted at some of the roles which video can fulfil in multimedia. The roles so far have been those already associated with video, such as motivation and links to the 'real world'. There needs to be more research to discover if the combination of video and interactive CAL creates any new possibilities for video. Other areas that need further research are the ways in which video may be integrated into multimedia, and consequential design considerations from both video maker's and educator's perspectives.

TerminalRISK was successful with a narrative, but the narrative relied on the user working through the package in the expected order, with each video sequence as a further short episode or scene, working the same way as any television or film narrative. The possible ways of building interactive narratives, where the user has control of the learning sequence needs investigation, as does the educational uses of such narratives.

The next chapter investigates some of these areas and looks at the creation of a package specifically designed and controlled by the experimenter for this research.

It should be noted that since this evaluation took place Price Waterhouse have updated *TerminalRISK* based on their own internal evaluation and on the findings of this evaluation. The consequent changes have been successful in addressing learner problems.

Chapter 4: Main Study: Phase One

4.1. Reformulation of the Research Problem

The findings of the preliminary study suggested a number of different areas relating to video in multimedia and the design of interactive educational multimedia that could be followed up with further research.

The preliminary study began to reveal some of the functions that video may fulfil in multimedia, though in TerminalRISK the video did little more than motivate the learner and help focus the program. The video was in discrete sections so that while it motivated the program's progression it did not add any information vital for understanding the subject of the program - computer risk auditing. Video can be integrated more fully into CAL / hypertext than TerminalRISK attempted. There are possibilities for greater links between video and other computerised elements. The video is able to contribute much more than it did in TerminalRISK. Investigation of this greater integration is one of the areas to be followed up in this chapter.

The structuring of the multimedia to allow the combination of user control and video narrative was also an area for further research that arose from Chapter Three.

TerminalRISK was linear: the student worked through the sections in sequence and so saw all the video parts in order. The video in TerminalRISK was little different from a normal linear video narrative. This Chapter investigates the issues associated with developing user controlled access to previously linear material. This will provide a way of judging the likely effectiveness of the, now commonplace, re-purposing of audio visual material in a multimedia format.

Issues relating to the design of multimedia were also raised in the previous chapter. These included the need for learners to be able to have knowledge of the program's structure and aims in order to govern their own learning strategies. The level and type of feedback available to students was also discussed.

This chapter follows up some of these issues, as well as those of narrative structure and learning from video that were raised in the literature survey, with the design and empirical testing of two multimedia programs that contain identical subject matter, but allow students different levels of freedom and program information. Both programs are based on an existing television program. One follows the structure of the original programme closely while only allowing limited user control. The other program contains the same information but students are allowed an increased awareness of the structure and are given greater control.

4.2. The Empirical Process

4.2.1. Aims

The study aimed to investigate further the issues raised in the preliminary study by:

- (i) making the structure of the material as explicit as possible;
- (ii) making available orientation tools designed to assist the learners in determining their learning strategy;
- (iii) adding the audio channel as a way of improving the learners' efficiency in interpreting explanations of the visuals.

The study also aimed:

- to examine the use and role of video's grammar in multimedia,
- to explore some of the issues involved in transferring an original video programme to a multimedia environment and in doing so uncover points for consideration for producers developing video destined for a multimedia platform.

In order to fulfil these aims, this first phases of the main study consisted of three parts: designing three contrasting video and multimedia versions of some teaching material, data collection, and analysis of data.

4.2.2. Designing the Materials

Selection of topic

There were several criteria in the selection of subject matter for the project:

- 1 It had to be material that the students were going to cover as part of their course. The learners were going to be asked to take time to carry out the study. If they could see that they could benefit from the study as it was part of a course that they had chosen to do, then they should approach the learning more positively.
- 2 There should be existing courseware material that can be adapted - especially video material, since shooting footage specifically for the project is time consuming and expensive.
- 3 The video material should take advantage of the strengths of video, such as conveying a particular viewpoint, supplanting thought processes, giving experience of the world and relying on movement or sound. It was important that the selected

material tried to convey more than a list of facts or figures, or even a simple formula or relationship.

- 4 The video should be of good quality and free of design flaws. It should have a good pedagogical basis and a successful previous track record.

It is very important in a study of this kind, that sets out to describe the characteristics of learning through a particular medium that the materials used should be of very high quality. Otherwise the findings will tell us more about the incompetence of the designer than the generalisable aspects of the medium. Laurillard (1991)

- 5 Since the selected material is to be changed and copied the legal aspects concerning this must be considered.
- 6 There should already be relevant and useful research in the area.

The area of science was chosen as a starting point for searching for a suitable topic. Science subjects satisfy point six above and there was likely to be material available to meet the other criteria. A further benefit of choosing science as the topic area is that the researcher has a background in science.

Year 11 students at a local school became the source of 'volunteers' to participate in the study (see the section 'selection of subjects' for details). The school presented a list of topics that the students would be working on and a search for suitable course material revolved around these.

The Open University already has carefully prepared texts in science as part of its undergraduate distance learning courses. Many of these texts include video that is either distributed to students on tape or broadcast as television for viewing or off air recording. These courses were examined and a number of possible course sections that include video were found in the science foundation course S102. These possibilities were presented to the science teacher at the school who selected the most appropriate one for the students.

The form of the selected video

The selected video was titled "The Earth - A Scientific Model". The general aim of the video and the associated text and diagrams was to show the benefits of using models in science and to show how scientific problems can often be clarified by looking at them from a different frame of reference. Specifically the Open University course material (unit) uses the examples of Foucault's Pendulum, the phases of the Moon and the retrograde motion of the stars to illustrate these principles.

The unit text states the objectives relating to the sections which the video covers as follows.

- 4 Describe the motion of the Earth with respect to the Sun...

- 5 Describe the motion of the Moon with respect to the Earth and the Sun...
- 7 Explain the phases of the Moon..
- 8 Explain the apparent motion of the stars...
- 9 Correlate systematic observations (such as the sequence of the seasons, lunar phases, etc.) with the features of a model...

S102 unit 1 p.44

The video runs for twenty four minutes and stands well by itself. The video does not make references to the printed material from the original course. Though the course does deal with the video's content in more depth the video does not need information in it to be understood.

The video fulfils point three of the selection criteria list well in that it teaches a viewpoint, a different way of looking at things. The 'phases of the moon' and 'retrograde motion of the planets' sections involve complex four-dimensional systems that need to be seen, and to be seen moving, in order that the student understands them.

The 'Foucault's pendulum' section takes place, partly, under the huge dome of St. Paul's Cathedral. The large swinging pendulum adds a dimension and experience which video represents well.

The complexities of retrograde motion are explained using processes of supplantation, as discussed in Chapter Two.

The program uses the televisual devices such as setting up expectations in order that it can thwart them later to make a point.

The video also satisfies point four of the selection criteria. The video has a good track record as it has been broadcast for a number of years as part of the highly regarded science foundation course, and is professionally filmed and produced by the British Broadcasting Corporation.

Selection of subjects

There were a number of considerations in the selection of appropriate subjects to participate in the project. It was desirable to have mature subjects since the study aims to draw conclusions as generally as possible about the use of multimedia in education and not be limited to considerations relating only to a specific age range.

The availability of subjects in sufficient number is also an important consideration. It was desirable that subjects should work in pairs so that they could easily vocalise their thoughts to each other. Thus finding learners that could be brought together to work in pairs was another consideration.

One possible source of students would be the Open University's own students. Due to the nature of the Open University's distance learning courses the only time it is feasible to get the students together is during one of the week long summer schools. Students' time during the summer school time table is heavily booked and inflexible. An empirical study would probably have to be included as optional in a free session, although these sessions are normally needed by the student for background work. A further problem with utilising Open University students at a summer school is that they only run for periods of a single week, and getting enough students through in one week would be tricky. Also due to time constrictions development of the multimedia system and the design of the empirical study in time for the summer school period would have been difficult.

Sixth form (16 - 18 year old) students were the logical alternative that could fulfil the required specification. Local schools were approached, and the Lord Grey School in Bletchley volunteered its students. Any single topic in the sixth form was not large enough to supply enough students so Year 11 (15/16 year old) classes were used instead.

Teaching content of the selected video

The video aims to teach some aspects of scientific thinking - particularly the benefits of looking at a system from a different frame of reference and the use of models to do this. The programme aims to demonstrate this by using three different examples; Foucault's pendulum, the phases of the moon, and the retrograde motion of the planets.

First of all the need to look at a system from a different angle is demonstrated in the introductory scene. The viewer is shown a shot of a pendulum swinging from above. However, the pendulum is not swinging backwards and forwards in a straight line as you might expect, but with a distinct curve. The viewer is asked to consider the reason for this strange movement. Anticipating the students' response of not knowing, the viewpoint of the scene is changed to reveal that the pendulum was swinging over a rotating child's roundabout, and that the camera was rotating with the roundabout, and that the pendulum was indeed swinging in a straight line in accord with Newton's laws.

This first scene leads into the first example in St. Paul's cathedral. The pendulum this time is suspended from the top of the dome. The example describes how Foucault measured the rotation of the earth using such a set-up. To understand how this arrangement works the viewer has to consider how the pendulum swings in relation to the earth in the same way as was necessary with the pendulum above the roundabout.

The second example moves from considering just the rotation of the earth to thinking about the movements of the moon, earth and sun. The example shows how it is possible to understand the phases of the moon by looking in on the relative movements and positions of the bodies from a frame of reference outside the system. To do this effectively a model in the

studio is used. A camera looking at the model from outside is compared with a camera mounted on the model earth to give the perspective of a person looking at the moon from earth.

The third example, continuing the theme of planetary movement, looks at the apparent retrograde motion of the planet Mars. The planet's path through the sky, when observed over a number of nights, seems to make a loop - at one point travelling backwards. The motion of the earth and Mars compared with the stars needs considering to understand this complex movement. Again a model in the studio is used to show the whole system from an independent frame of reference.

4.2.3. Comparison of the Video Against Koumi's Framework

This section compares Koumi's (1991) framework of narrative educational television screen writing (from Chapter 2) with the selected video. This comparison will help show how the original video was designed to work, and is an example of how educational narrative television is designed. A detailed look at the structure of the program in this will also be useful in determining some of the differences between linear video and multimedia video.

This section refers to *figure 4.1* (which is identical to figure 2.1) and to the section "Argument Construction in Video" in Chapter 2. During the analysis of the video I will include numbered references to this table. For example 'B3Ra' would point to sub-table 'B' (structure), section '3' (Do it with sympathy), subsection 'R' (Reinforce), item 'a' (Repetition).

Some of the points in Koumi's table are not attributed to a particular part of the narrative in the discussion below. This is because they cannot easily be attributed as belonging to a certain section. For example section C2d says 'don't mesmerise': the editing of the video is such that it does not mesmerise, but this cannot be attributed to any single section of the video.

The considerations in sections A1 and A3 of the table, which specify the target audience and educational objectives, remain the same for both the design of multimedia and television. However the learning context will be different since multimedia will integrate differently into the students' course and require different support from other media (section A2a).

For this study the target audience has changed from the originally perceived target audience of Open University undergraduates. The video assumes little specific previous experience or knowledge so the change in target audience does not have the impact that it would had the video been targeted at a more specialised audience.

Section B1 of the table outlines the structure that each section of the video might take. Educational video does not need to follow any sort of formula in this way, but the structure

described is well known by teachers: make them want to know (B1), tell them what you'll do (B2), do it (B3), tell them you've done it (B4) and then connect it (B5).

This structure can be can be applied to the video as a whole or to each section or chapter of the story.

Analysis

The video begins with the hook - the pendulum swinging in an inexplicable way. The presenter says:

The pendulum does seem to be swinging in an odd sort of way, doesn't it?	B1a Appetise C2c Pose questions C2b Pause for Contemplation
But then of course things aren't always like they seem to be. It depends how you look at them.	B1b Surprise B2 Signpost

The very beginning of the video aims to appetise / create suspense by making the viewer question the odd movement of the pendulum, the suspense is raised further in the second statement about the programme revealing that things are not what they seem to be. The frames of reference theme is sign posted in the next sentence: "It depends how you look at them".

Next a long shot of the roundabout reveals the reason for the strange motion. The relationship between the two views is reinforced with a zoom in and the first view is repeated to further clarify the relationship. During this sequence the presenter describes what the pictures show and directs the viewers' attention:

Narrative Screenwriting for Educational Television Koumi(1991)

A. THREE USAGE DIMENSIONS

How is the programme to be used: by whom, in what context, for what purpose?

1. Target Audience
a. Culture
b. Age
c. Commitment: general/student body
d. Previous Experience / Knowledge
e. Facilities, e.g.: owns/shares a TV?

2. Learning Context and Complementary Learning
a. Other media: e.g. class teacher, other TV, audio, print other students, computer
b. Pre-Work, post work
c. TV vs. stop-work-start video

3. Educational Objectives
a. Affective (feeling, appreciations) e.g.: reassure, fascinate, personalise
b. Motivational (urges) e.g.: mobilise, stimulate diligence
c. Experimental e.g.: concretise, explore, demonstrate
d. Cognitive e.g.: knowledge, concepts, strategies

B. STRUCTURE.

Each chapter of the story

1. Make them want to know	Hook (but no false promises) a. Appetise / Create suspense b. Surprise / Excite / Dramatise
2. Tell them what you will do	Signpost a. Set the scene / introduce b. Distant Signpost: What's coming? c. Chapter Heading: What's next? d. Focus: What to look for
3. Do it: with sympathy	[T] Texture the Story a. Non-Linear / Non-sequential b. Vary Format c. Vary Mood / gravity d. Structural Pacing
	[R] Reinforce a. Repetition b.. Re-exemplify c. Compare / Contrast d. Dramatic Climax
	[S] Sensitise a Seeding b Consistent Style c. Music Style / Occurrence by Design d. Signal Change of Mood /Topic Consolidate / Conclude
4. Tell them what you have done	a. Recapitulate b. Summarise Salient Features c. Generalise / Extrapolate d. Chapter Ending Link (make story hang together)
5. Connect it	a. Content-Link Between Items b. Story-Link / Hand-Over / Pick-up.

C. Sympathetic PICTURE-WORD Composition

1. Producer Into Viewer's Mind: what is the viewer thinking / looking at?
a. Words reinforcing Pictures & vice versa
b. Optimize Load, Pace, Depth
c. Enhance Legibility / Audibility
d. Grammar of TV
e. Communicate assumed external knowledge

2. Producer Out of Viewer's Mind Don't blinker / Allow mental elbow room
MINDFUL learning by a RANGE of viewers
a. Words NOT DUPLICATING pictures
b. Pause for Contemplation
c. Pose Questions
d. Don't Mesmerise
e. Reveal Geography
f. Reveal Concept-Environment
g. Professional Integrity

[long shot] You were looking through the camera on the roundabout. Now, just concentrate for a moment of the line joining the centre of the roundabout, [zoom in to pendulum] where Emily's holding the pendulum, to where I am. Is the pendulum really changing its direction of swing?	C2f Reveal concept-environment C2e Reveal geography
[close up of pendulum swinging] But it did look different viewed by the camera on the roundabout.	C1d Grammar of TV
[pause]	C2c Pose Questions B3R Reinforce
	B4 Consolidate / conclude C2b Pause for Contemplation

This short sequence uses the narration to reinforce the pictures and vice versa {C1a - words reinforce pictures & vice versa} while they do not duplicate each other {C2a - words not duplicating pictures}.

Next a long shot is used to break away from the specific example and allow the presenter to talk in more general terms {C1d - don't mesmerise}:

[long shot] Something that's happening in a frame of reference that's rotating is going to look different from what it will look like in a frame of reference that isn't.	C1d Grammar of TV B3Sd Signal change of mood / topic
	B4c Generalise / Extrapolate B4b Summarise salient features B2 Tell them what you have done

This section summarises the introduction so far by generalising the example and extrapolating the findings. It also serves as a further signpost for the rest of the programme.

This next scene shows the presenter:

Now I guess, Ian and Emily, you'd better take a bit of a rest or you'll be getting giddy or something.	C1d Grammar of TV B3Tc Vary mood
--	-------------------------------------

This last statement clearly has nothing to add educationally (Ian and Emily are the cameraman and the girl holding the pendulum, and are both on the roundabout), but it does give a pause and varies the mood and gravity {B3Tc - vary mood}. This varying of pace further helps to dismiss the specific example (and Ian and Emily) to allow the presenter to talk more generally for the moment:

This simple demonstration illustrates a basic idea about scientific thinking [zoom in on presenter] . If we want to understand a situation or a phenomenon we often have to take off from outside of the restricted framework of everyday observations and in our mind's eye [long shot with roundabout and presenter] look at things from a different viewpoint.

C1d Grammar of TV
B3R Reinforce

B3T Texture the story
B3Sd Signal change of mood

B3R Reinforce

The zoom in is a grammatical function that draws attention to the presenter and what he is saying. The cut to a long shot helps vary the pace and mood. It is motivated by the idea of looking from a different viewpoint, and helps emphasize this. This cut is also preparing to re-introduce the specific roundabout example in the next shot and to begin to conclude the section (in the section above notice the close up of the pendulum swinging even though Ian and Emily have gone - the shot is a backward reference and not bad continuity):

So a swinging pendulum like this can look [close up of swinging pendulum] quite straight forward and simple. But in the frame of reference like the one that Ian and Emily were in it can look a good deal more complicated.

B3Rb Re-exemplify
B3Ta Non-linear

B3R Reinforce
B4 Consolidate / Conclude

Following this there is a cut to a medium shot of the presenter to signify moving away from the pendulum example and back to more general explanations as the presenter begins to link this section to the general argument of the programme and the next section:

{medium shot of presenter}
Now, as you know, the Earth
has something in common
with the roundabout. It
rotates about its axis and it
also orbits round the sun.

B3Sd Signal change of mood / topic

So things seen from the
surface of the earth like the
rising and setting of the sun
and the phases of the moon
are likely to look a lot more
complicated than they
really are.

B3Sa Seeding

To make sense of these
phenomena, the early
astronomers had to make an
extraordinary leap of the
imagination to escape from
the earth-bound context of
things as they seemed to be
and view them from the
vantage point, as it were, of
the gods and angels.

B3Sa Seeding

[zoom in to presenter] No
wonder they were accused of
blasphemy at the time.

B3Tc Vary mood / gravity
C1d Grammar of TV

The zoom in focuses the viewers' attention back to the presenter as he outlines what the programme is going to do.

Now we've chosen to tell the
story of how the present day
model of the solar system
fits with observations from
the earth, because this
illustrates a basic thing
about scientific thinking:
the importance of mental
detachment and of
imagination.

B2 Signpost

The next sequence signifies a change of mood. There are inspiring music, pictures and sound effects as the presenter talks about leaps of imagination. This section is still part of the introduction and is acting as a general hook to appetise the viewer for the coming examples.

{B1a - appetise}{B1b - surprise}

[Sound effects of Sea][Time-lapse sunrise sequence][music "One Small Step"] Scenes like these have fired the human imagination since time immemorial but more often in the Arts than in Science. Yet it did require imagination to perceive these every day events as they actually are, rather than as they seem.

B3Sc Music style / occurrence by design
B3Sd Signal change of mood / topic
C1d Grammar of TV

B3Rb Re-exemplify

[Time-lapse phases of the moon] After all, it's so much easier to think of the heavenly procession of sun, moon and [still: Star Track], stars across the sky as being due to their motion around the earth. Nowadays millions of [still: Earth from Space] people have seen the earth from afar through pictures like these.

B3Sa Seeding

C1a words reinforcing pictures & vice versa
C2a words not duplicating pictures

The mental leap has been made and the earth is easily visualised as a giant roundabout with us as passengers on it.

B3Rb Re-exemplify

So shouldn't we expect to see effects on the earth that we saw on the Children's Roundabout? {B5a}{B5b}

B5a Content-link between items
B5b Story-link / hand-over/ pick-up

The link to the next section is made. The next section looks at Foucault's pendulum and what can be learned about the movement of the earth.

This section follows Koumi's framework and demonstrates the complexity of the narrative construction in even a simple sequence like this introduction.

A similar analysis can be made for each section in the video and of the complete video.

4.2.4. Design of the Program

The two multimedia programs

Two multimedia programs were written using HyperCard on the Apple Macintosh computer. Both versions contained the same material carefully selected from an existing Open

University course unit. The programs were based on material taken from one of the videos that accompanied the unit. Both versions had the same aims and content, the only difference being the structure and the presentation.

The linear version

The linear version retained the linear structure of the existing video. The user was only given the controls to move backwards and forwards a page at a time. The video easily segmented to allow each page (HyperCard card) to contain an argument point. Each point consisted of a short paragraph of text and (normally) a short video or sequence of stills. The text was taken from the original script, the only changes being motivated by the differences between spoken and written text. The video sequences and stills were digitised from the original video. In the end the whole argument of the video was covered in the same detail as the original.

The linear version is thus structured in a similar way to the original video, the difference being that the user controls the pace of learning and has the option to review sections by stepping back through them.

The structured version

The structured version also kept the overall structure of the linear video but made this structure more explicit, allowing the learner to locate and go directly to a section.

This structured version provided other orientation tools such as 'percentage complete meter', 'marking of read sections' and an 'audio summary' of the card option.

The percentage complete meter took the form of a solid black line that extended along a graduated scale each time the user visited a card they had not seen before. The graduations ran from 0% to 100%. From this gauge students could get instant visual feedback of how much of the total program they had visited, and how much more there was to go. A numeric percentage readout was included with the gauge to increase clarity.

Menu items and sub menu items are marked with a tick and a note saying 'read' once the user has visited all the cards below that item. This marking enables students to see which sections they have covered and so they can also tell which sections they have not covered. If students think that they have completed a section, but it has not received a tick then they know that they have missed something in that section.

The structured version uses digitised speech to give an audible precis of each page of information as the user turns to it. The voice summarises in a few sentences the key argument of the card. It was hoped that the voice would go some way to replace the presenter in the original video, while not requiring his dominant role. It was also hoped that this audible information would allow students to quickly assimilate the purpose of the card giving them

the opportunity to link it to the previous card which should still be in their minds. Spoken information does not require as much processing as written text, and also contains cues that cannot be included in text. Also sound is of an obtrusive nature that cannot easily be ignored. It was possible, and very likely, that students would quickly pass over cards without fully reading their contents, but it is difficult not to listen and interpret a short spoken message. On each card there was an icon to click that would repeat the speech for that card.

For example when students arrive on the card with the video of the pendulum swinging oddly the spoken message says: "How can a pendulum swing like this?". And on the introductory card to the moon phases section the voice reminds the user of the theme of frames of references by saying: "To understand the apparent changes in the moon's shape we need to look in on the system from outside."

The two multiple media versions of the programme were to keep the same content, though one was designed to keep the same structure and accessibility, and the other was to add hypertext / multimedia features to allow easier access and an explicit structure. It was originally hoped that both versions would contain most (if not all) the original video, and would simply alter the way of accessing this material.

During the creation of both versions it became increasingly obvious that such a straightforward conversion was not sensible, nor in some respects possible. During the design process it became clear that some elements of the video could not be converted to multimedia format. Some had to be altered and others could reasonably be left the same.

4.2.5. Technicalities of Design

Video capture, Quicktime, digital editing

There were two possible ways to introduce video onto the computer screen. The first possibility was to use modern video disk technology to convert and pipe analogue video onto the computer screen, as the TerminalRISK program did (see chapter 3). This would have the benefit of the video images being high quality and smooth. The drawbacks of this are that video disks are expensive to press for just one copy, the hardware is expensive and the video is not integrated into the multimedia environment as well as digitised video .

The second option was to have the video pre-digitised and compressed and to play it back from the hard disk.

Video requires that a series of still images be played in quick succession to give the impression of movement. British television plays 25 of these 'frames' each second, American television sets work at 30 fps. At these speeds convincing smooth movement is possible. The

number of frames per second can be lowered to 15 or even 10 fps, and the illusion of movement remains, but lower it any more and the video becomes too jerky and distracting.

To transfer the analogue video or film image into the digital domain for use on computers requires that each frame be digitised. A true colour picture of about 350 by 280 pixels would normally require between 300 and 500 kilobytes of storage. Even the lowest acceptable frame rate of 10 frames a second would require the data to be transferred off the storage device at around 4 megabytes a second – a speed which is much too fast. In order to play video from the hard disk this figure must be reduced to beneath 1 megabyte per second, a speed at which most hard drives operate. To do this the video information must be compressed. Two ways of doing this were investigated.

The MPEG (Motion Pictures Experts Group) standard of compression gives good control over the image size and playback speed. MPEG technology requires much processing power to decompress the information fast enough to keep pace with the video's thirty frames per second. Because of this processing overhead the extra work is best carried out by a dedicated hardware extension. At the time of program development the MPEG standard had not been fully agreed and there was a lack of support from authoring systems that would have meant lengthy programming times using low level languages.

Apple's QuickTime was the other digital video option. QuickTime provides a way of playing video directly from hard disk storage into a window on the screen of Apple Macintosh computers. Unlike MPEG, QuickTime is a software only extension to Apple's system software. Although there is no dedicated hardware for the video decompression there are greater limitations. To achieve frame speeds greater than 10 fps the image needs to be small. The quality of the image also relates to playback speed: a highly compressed video clip may be larger, or play back more smoothly, but it is at the cost of image quality. QuickTime provides a synchronised sound track, although this costs quality and playback speed. The benefits of QuickTime video are that it may be played independently of any specialised video hardware enabling distribution in software only. It integrates well into existing Mac software – video windows can even be inserted into word processor documents to make active documents possible. QuickTime video can be integrated with existing Mac authoring systems such as MacroMind Director, or HyperCard. These authoring systems allow fully functional multimedia programs to be written and altered easily.

It was clear at the time that using the Macintosh and QuickTime was the most flexible solution despite its lower picture quality.

Video digitising hardware needs to be used in order to 'capture' the video into the computer environment. The Video Spigot card was used to capture video for the study. The video was taken from a VHS copy using the composite video input of the Spigot board. The video was

edited, re-sized and compressed using Adobe Premier. Many video clips were cropped so that they would only contain essential information and so would run better. The final videos' sizes were between 160 by 120 and 190 by 145 pixels big. At this size the video would play at 10 fps or faster, on the 8 bit colour Macintosh IICx that the study used.

Hypercard

The systems were implemented using Apple HyperCard 2.1. External commands were added to the stack to add the extra commands needed to control QuickTime, to make better use of sound and to display the percentage complete meter. The advantages of using hypercard were that a working system could very quickly be built, and modifications and fixes could be made with little fuss.

4.2.6. Design of the Empirical Study

The study was carried out at the Lord Grey school in Bletchley, with students from Year 11 (15/16 year old) studying physics.

There were three different conditions in the study:

- (1) 25 students watched the original video.
- (2) 10 pairs worked with the linear multimedia.
- (3) 10 pairs worked with the structured multimedia.

For condition (1), a class of twenty five students was shown the original video. Unlike the students in the other conditions who worked in pairs, these students watched the video as a class and answered the questionnaire as individuals. The difference in between these conditions was not thought to be important for this study is empirical, looking at what happens, rather than a controlled experiment. The students completed a printed pre-test (appendix C) that covered similar questions to the spoken pre-test during the multimedia studies, before viewing the video. The video ran for about twenty five minutes. Afterwards students answered the printed post test. Both pre and post tests required the students to draw diagrams to help their explanations. The students also answered more general questions about the program that matched the type of questions that were in the interview. Students worked individually to complete these questionnaires.

Five of the students who watched the video had also worked with one of the computerised versions.

For conditions (2) and (3) students using the multimedia worked in pairs normally mixed in gender. Pairs were chosen so that they would discuss what they were doing with each other,

and so give the experimenter better opportunity to assess their strategies. This is a similar approach to the one described by Mayes, Kibby and Anderson (1990) in their investigation of learning from hypertext. The pairs were selected by the head science teacher, and were chosen so that the pairs were balanced in ability, but between them represented a range of motivation and ability. Care was taken to make sure that pairs of an equal spread of ability tackled both program versions.

Before students worked with the multimedia they were given a spoken pre-test to establish what they already knew.

While the students were working with the programs they were carefully observed, and their attitudes, comments and activity in the program were noted. The students' conversation was recorded on audio cassette. Students were left to complete the program uninterrupted by the experimenter who did not intervene unless the students had direct questions or problems. The few students who asked questions during the study were directed back to the program for answers.

Students worked with the program until they were finished, there was no time limit set. Students took between 20 and 30 minutes to finish the programs.

The hypercard programs also tracked the students, recording the order of cards visited and how long the pair stayed on each card. The program also noted their activity on the card, how many times they went through a sequence, how many times they watched a video and if they repeated the audio on the structured version.

Following the study was a post-test. The questions on the post test aimed to assess the students' understanding of the arguments within the program rather than their retention of certain facts or figures. Some of the questions required students to draw diagrams of the systems dealt with in the programs. Since the program dealt with quite complex four dimensional issues, giving the students the opportunity to express their answers visually, rather than just verbally, seemed a good way of getting richer and more detailed answers. Any sort of diagram which the student draws has more detail than the student saying 'I'm not sure about that'.

Interview questions also aimed to determine how students thought the sections related to each other and to discover what students thought the central argument of the program was – was it about the pendulum, moon and planets, or about scientific thinking and the use of models?

The interview also aimed to find students' reactions and attitudes to the program, and to pick up on any areas noted as being interesting when they were working with the program.

The ideas that are discussed in the “Findings from the Construction of Multimedia Video” section came out of the process of making the video - they arose not from any formal method but rather as a result of someone who is used to one particular media noticing the differences when they work with another. The findings from the empirical studies are arrived at more scientifically. Data collected through observation, interviews, tests and by the computer was examined systematically with the aim of finding experiences / problems that at *least* two pairs of students had in common. Any common feature was examined to see if the data collected supported the finding or not.

Interviews, pre and post-tests were recorded on audio tape and transcribed later.

The next section considers findings from the construction of the video before going on to consider the findings from the study.

4.3. Observations from the Construction of Multimedia Video

4.3.1. Points Raised During the Construction of Modular Multimedia Video

Constructing the multimedia program from the linear video was a valuable part of the study, and the process revealed a number of key points of difference between the two formats. Investigation of these differences should reveal something of the nature of the use of video in multimedia.

The following sections are issues that became salient during the development of the programs used in the study. They raise questions rather than answering them, and although they discuss possible differences and ways of working with them, as with all aspects of video production, these cannot be considered as rules so much as guidelines that a producer can consider.

4.3.2. There is No Role for the Presenter

During the conversion of the linear video for use in the multimedia programs it was necessary to consider the role of the presenter.

In the original linear video the presenter is the viewer's guide to the video. It is the presenter's responsibility in the context of the video to guide the viewer between sections, introduce other people and present the details of the video's argument. If the video is sectioned and put into a hypertext / multimedia environment then the presenter's role is changed. No longer is it the video presenter's job to guide you between sections since the learner decides their pace and route, neither does the presenter need to introduce other people in the video since this is probably better done by another element of the multimedia. A

presenter could still be used to present an argument within a video section, but without the other roles, the presenter's authority has been eroded.

The original linear video was presented by two Open University academics. Little on-screen text was used, apart from the titles and closing credits, so the commentary was spoken. It is possible to categorise the visual corresponding to a presenter as follows: a) the presenter is shown in a 'head and shoulders' shot talking direct to camera; b) the presenter is shot talking about / showing something else in shot; c) the presenter is talking off screen as a voice over to a sequence. Each of these situations required different consideration. In point (c) the presenter is not seen, only heard. If a sequence containing a voice over from a presenter is shown but the presenter is not seen, then this gives the possibilities: either keep the presenter, replace the presenter's voice over with another voice-over, or replace the voice-over with text.

Talking heads, often filmed as a 'head and shoulders' shot, are used in video for different reasons. Often an expert is shown talking like this, for example a member of parliament, scientist or eye witness. In these cases we are being shown what this particular person said in order to give it credibility, authority or authenticity. When the presenter in video is shown in head and shoulders shots it is normal to link between sections, and to provide a 'home' shot to return to between cutaways and other sequences. Seeing the presenter does not add extra credibility to what is being said. In modular multimedia, video links like this may not be usable in the same way and may be better done another way.

When the presenter is in shot to demonstrate or talk about something else in shot his job can be to interact with the video's environment on our behalf, his experiences being a substitute to ours. The role of the presenter in this situation must still be of importance to multimedia, though since the presenter's status has changed for the reasons above, his inclusion in these shots becomes tricky.

In the light of these considerations in the conversion of the linear video to multimedia the presenter when not seen or seen as just a head and shoulders, was replaced by on-screen text. This is not a good solution in all circumstances since too much on-screen text is wearing on the users and some text could be better presented as audio.

Video that had the presenter and other objects in shot were kept, though sections of the presenter talking were cut. This too was not ideal, but because the presenter had not been seen at other times his appearance in these shots was strange, especially when his speech implied an authoritative role. In some of these sequences the video was designed to pause at key points with text displayed alongside it and the user continuing the video after finishing with the text.

4.3.3. A Person in a Video Window is Too Small to Talk

A talking head on video normally requires the full attention of the viewer. Existing television conventions normally require the shot length to be appropriate to what is in shot. If the subject is not talking about something that is in shot the viewer would not expect to see their full height. Instead the viewer would perhaps expect to see just the head and shoulders. If there was anything more in shot the viewer would be trying to assimilate 'why' it is there. Davis (1969) in his book of grammatical rules for television says: "The ideal length of a shot is one that will just contain the essential action." Davis (1969 p29). Similar consideration should be given to video in multimedia. Thought must be given to what else is on screen with the person in the video window, perhaps balanced against the importance of what they are saying. If what is being said is important to the program then it may be better to use full screen, rather than a window.

In the study the size of the video window attainable was limited by the technology. The smaller the window used the less important the person in the window appeared. A video window not containing a talking person seemed to work better. The area surrounding the window can be very useful if has information which is relevant, giving context or a useful contrast to the window's contents.

4.3.4. Text Must Match the Video

A user will normally read text on screen in preference to watching a video segment if both are provided at the same time.

During the construction of the multimedia programs a number of different ways of displaying text with a video segment were trialed. Several methods were tried on different subjects to determine which to include in the program. If both text and video (which is playing) are presented simultaneously the user believes, quite correctly, that the text relates to the video, and assumes that the text may be important to understanding the video and so tries to read the text first - at the cost of missing video detail. Could this indicate that the viewer believes that what is written in text is of more importance than the content of the video?

As a solution, when the video reaches a point at which text is to be displayed the video is paused and then the text displayed. Once users have read the text they are free to continue the video. In this way the user has the opportunity to read and consider the textual note without rushing or worrying that they'll miss some video content.

Users preferred the text to be erased from the screen as soon as they chose to proceed rather than being deleted once the section had finished or the next text was to be displayed, even if the text was still relevant to the video.

4.3.5. There Must be Alternatives to Video Links Between Sections

The links between sections in a video are important: it is because of these links that an argument is created and not a sequence of unrelated points.

If short video sequences are to be used in multimedia, and it is not certain which section the user will go to next, or when they will arrive, then these types of links cannot be used in the same way. It is the user who specifies their own links, since they choose when and where they are going next, based on what they have already seen. If users are to interpret the argument correctly, and make the links and decisions which the educator feels are necessary, then it may help the users to have the contents of each new node summarised as they arrive at it. This is done in the structured multimedia: as the user moves from card to card, and between sections, an audible précis of the new card or section is given. In this way, even if users flick through the cards fairly quickly they have heard a spoken argument of their path. If the contents of a new card are made clear as soon as the user arrives at it then the user will be able to understand the link between the new point and the previous one while the previous information is still being considered. Users can then approach the new information with some knowledge of where they are going.

4.3.6. Users Have Greater Awareness of the Video's Construction

Video and especially television can be used to portray events as if they are 'real' even if they are not. Television producers make a great effort not to present anything which might draw attention to the fact that the viewer is watching an artificial construction. Of course all viewers can distinguish the difference between real life and television, but viewers are happy to allow themselves to enter the illusion of 'reality' while they watch. This is part of the attraction of television and anything that disrupts this illusion is unwelcome and can end up with users thinking about the production of what they are watching (E.g. 'how did they get that shot?') rather than the contents. The users of video in multimedia are much more aware that what they see is a construction. They have control over the pace and sequence of the video. The video is split into sections and may be found in small windows rather than occupying the full screen. These factors will heighten awareness that it is a construction and will not allow the viewer to suspend disbelief. In the construction of the multimedia in the present study, for example, the presenter says "we are going to *attempt* to reconstruct the experiment" the word 'attempt' has a sense of immediacy in the linear video, as the viewer is tempted to believe that the experiment might not work, and that it is being carried out in real time. This effect is lost to an extent in the multimedia since the viewer is in control of the sequence and progress instead of following an unfolding narrative. Consequently the viewer no longer feels that the experiment might fail. This may be a problem for video

sequences with a motivational objective, sequences that the viewer is meant to associate with, or drama sequences the viewer is meant to empathise with. However, this needs more investigation.

4.3.7. The Perception of the 'Author' Changes

In the multimedia program, the presenter at one point says 'we have built a model in the studio.....' this tends to jar when put in a multimedia context. There may be a number of reasons for this. It is possible that it seems wrong because the presenter in a linear video has some authority, being the authorial voice. On the other hand, in the multimedia version the presenter has no control over our viewing or usage of the material, and anyway he is encapsulated within it or is acting as an adjunct to another author's text. It may be that for multimedia use any person speaking within a video clip must have their authority established by some associated text or audio whenever that clip appears.

4.3.8. Sound Must Match Screen as well as Window

The sound of the presenter talking in the original video was different when it accompanied the video window on multimedia. The sound seemed to fit the original video better. There could be a couple of reasons for this. Firstly, the video image on multimedia was much smaller, but the sound stayed the same 'size'. And secondly, the screen no longer just contained the video picture, but other elements also. While the sound was playing perhaps it was also referencing the other elements on screen

Similarly one shot from the original video had background sound effects of bird song. The sequence showed a pendulum that was swinging oddly. It was apparent that the image and the sound did not match. This worked in the original video as a cue, or even a little joke for the next part of the sequence which was of the same pendulum, but from a different frame of reference. The new shot revealed the reason for the pendulum's peculiar motion, and for the bird song. It showed the camera man from the previous shot filming the pendulum standing on a rotating childrens' roundabout in the park, the pendulum suspended above the rotating roundabout.

To have left the bird song sound effect on the first shot in the multimedia version would have been distracting. The video in the multimedia version pauses between the first shot and the second shot where the reason for the peculiar motion is revealed. At this point the viewer is asked the rhetorical question "Why does the pendulum swing strangely?". The student in answering this question on the multimedia version is likely to consider the bird song as somehow relevant, but it is not any part of the solution. In this way what had been a background sound became too prominent.

4.3.9. Care Must be Taken When Using Questions to Guide Discovery

It is normal practice in a video to raise topics or questions that the viewer has not yet understood. The viewer is normally quite happy with the video going on to explain what has just been said. When the progression of multimedia is under the control of the user, it is then the user's responsibility to go on to find what to do next. If users cannot understand the argument fully at their present position then they will be unsure of their next step. For this reason, as in computer based learning, a default option should always be available.

Viewers of traditional video do not have this problem of course, since they have no option about direction or pacing of the video.

4.3.10. Multimedia Offers New Options for Screen Format

Many multimedia applications to date have used video windows rather than full screen video. There is an on-going debate over which is more appropriate. Users of analogue video from videodisk have until recently been limited to using full screen, because to insert a video window into a computer screen really requires that the analogue signal be digitised. Users of digital desktop video had, until recently, been limited to video windows due mainly to the processing times of fetching and processing the digital data. Now, however, multimedia producers have the option of which to use.

During the conversion of the original video to multimedia it was apparent that it was possible to reframe the image clipping the edges off so that the picture just contained the object of interest. This would have helped focus the viewers' attention on a specific part of the image. The original video images, though, were already composed for the television screen and did not need re-framing. Producers of video for multimedia have the added flexibility of being able to change the image ratio if they desire and not being restricted to the set aspect ratio of the television or film screen.

Some of the video sequences were reframed for this study, the reason for this being purely technical. The small image size meant a loss of detail. Sequences that particularly suffered from this had their point of interest enlarged, but were reframed so that they were the same size and aspect ratio as the rest. Learners may have found video sequences of different sizes or ratio for no apparent reason confusing.

A video window in multimedia need not maintain the aspect ratio of existing television or computer monitors. Tall thin windows or circular windows are possible. In fact even irregular shapes such as a window shaped as a question-mark are possible. The question the producers must ask is 'is it appropriate?'. Davis, when talking about shot angle for television, suggests:

Avoid shots that are wider than they need to be to contain the action and, even more rigorously, avoid shots that are too close to contain the action.

Davis (1969)

There are few cameras at the moment that will record in other ratios, so any changes must be planned carefully so as to confine the action to the area to be used. It is possible to clip unwanted areas from the image during editing.

A further consideration in using video windows is what to do with the rest of the screen. If the rest of the screen is unrelated to the video - just the computers' desk top or remotely related program text, then this backdrop cannot really be said to add anything to the currently playing video. What the backdrop may well do is put the video in context. A graphic in the background can indicate something about the current video, and could be changed during the video, to signify changes of emphasis in the video. Keeping the current tutorial text as a background may help anchor the video's place in the course in the students' minds, telling them that this video belongs with this section.

Full frame video on the other hand takes up the whole computer screen, demanding more of the students' immediate attention. Students may expect full screen video to be more like television and feel more inclined to let it play uninterrupted. An overlaid graphical control panel may help. Perhaps talking heads in full screen video will sound more credible and authoritative. The deciding factor in making decisions like these will be the type of program and its aims. It is likely that consensus of using different formats will develop and grammars will evolve out of use.

Perhaps the most important rule in video grammar is that there must be a reason for whatever you do.

Any change of picture tends to attract the attention of the audience away from the subject matter and towards the technique, therefore never change it unless the next picture says something different, that has to be said, something that emphasises a point or adds to comprehension of the audience. Never change a picture for the sake of change; it is a mere distraction.

Davis (1969)

Any action without motivation will mislead the viewer. It is probably fair to say that this applies for multimedia production too.

4.4. Findings from the Empirical Study

4.4.1. Use of On-Screen Text

Each screen of the program contained a few paragraphs of text. The text was paraphrased from the script of the original video. Care was taken to keep the amount of text on a page to the minimum necessary. The text then took the place of the original commentary.

The structured version provided a voice-over summary of each page of information as the student selected it. This encouraged some students to avoid reading the text.

Ian: Didn't read much of it, just watched the videos

Q: Did you feel that was enough?

Stephanie: It's easier to listen to it and watch it, don't have to read it at all

Pip: Yes, you listened to the sound and then you read it for yourself and its more detailed and then a little voice tells you whether you want this page, this is about this bit, then you don't have to read this bit because it's just told you that.

Students did find the voice useful in that they felt that they understood the contents of the card quickly. Unfortunately, for the less well motivated students who felt that they did not have to read the text, this carried the detail that was necessary to really understand the material.

A possible solution for this would be to make the speech more detailed. The text on the card could then either match the speech or high light the main argument points. Having detailed speech that did not match the text would require too much effort to take it in at the same time (Salomon, 1984). One student describes how he sees the voice doing this for him:

Q: Why would that [the voice] help?

Simon: Why would that help? Well, it like feeds ideas into your head

Q: Right, but you could have got those from the written summary

Simon: Oh, you could, yeah, but I'd rather have to listen to a voice, because you have to, you can't not listen and you can not read text, because you can just read that and you wouldn't take it in.

The unavoidable nature of sound used in this way warrants further research. None of the students said they found the sound intrusive or annoying as might have been expected, though this may be different in another environment or with different subject material.

Pip was part of one of the few pairs that went back into the program later to check one of their post-test answers. She suggests that the spoken precis would help in finding information when she went back.

Pip: No, when you're first going through, it summarises that bit and explains it a little bit, but then if you need to go back to something it helps you.

Use of sound could affect how students spent their time. The average time spent on each card in the structured version was around three quarters of the time spent on the linear version. This is probably because students did not need to spend as much time reading each card because of the spoken precis. Another possibility for the time differences between the two versions was that with the ability to navigate the structured version better as well as the extra information of where the students were and how much more they had to do, students felt that they were able to return to a card or a section later if they found that they had not fully understood its argument. In the linear version, on the other hand, there is likely to be more of a feeling that once the card has been left, it would take some effort to return later, and so more effort is required during the first reading.

Students from both versions were more likely to read the writing that was associated directly with a picture or video rather than read a textual section that stood on its own. This was apparent from observation of the student pairs where students did not show signs of reading activity (such as reading out loud or with lips moving) or spend enough time on the card. There was evidence that students read the text beneath a picture / video or sequence. These sections in particular were the ones which were read out loud or ones which caused the students to pause between sections of a sequence.

Stephanie: I just listened to it and then read the bits underneath the pictures

Ian also admitted to looking at the 'pictures' rather than reading

Ian: When I looked at the diagrams [I] didn't know what they were going on about properly, so I never read through the things.

Nichola also felt that the pictures contained enough information necessary to understand the programme.

Q: I noticed you didn't read much of the text, did you feel that you didn't need to?

Nichola: Well, I did feel like I didn't need to, but I should have read it

Q: Why did you feel like you didn't need to?

Nichola: I don't know, I just thought the pictures would help me learn it.

The problem partly lies in the fact that students believed that they sufficiently understood the argument at the time, but when questioned in the post-test they then realised their understanding was too weak to be applied to answer questions later.

Stephanie: ... when you asked the questions I didn't remember anything about it

Students had more problems understanding the written sections than the spoken precis.

Stephanie: It's not that it was the amount of writing, it's just words that you don't understand and the way it was wrote. It's a bit too complicated for us

Q: Right, OK, do you think it would be better if there was more speaking ? Did you find the speaking useful?

Ian: Yeah

Stephanie: Yes, listened to that

Q: Did you understand that all right?

Stephanie: Yes

Q: Were there any words or complicated grammar there in the talking?

Stephanie: I can't remember

Q: You can't think of any places where you didn't know what he was talking about?

Stephanie: No, I can't think of any places

Q: Do you think it would be better if there was more talking and less writing?

Ian: Yes

Stephanie: Yes, does the talking just summarise what it says?

Q: Yes

Stephanie: Cause I understood what it was saying and that, so if it just says that then maybe there's nothing else to put in it

Q: So you don't think there's anything extra in the writing which the talking didn't say

Stephanie: I don't know cause when you asked the questions I didn't remember anything about it

4.4.2. Changes in Conceptions

Students who completed either multimedia version, or the video version all shared common misconceptions.

Since students have some basic knowledge about the solar system it was possible to ask them questions about the moon and its phases in the pre-test and post-test and so show how their misconceptions changed after they had finished. This was not possible with Foucault's pendulum or the retrograde motion of the planets since these were entirely new to the students before they saw the programs.

There were three misconceptions that students were prone to suffer from: the earth casts a shadow on the moon, something blocks our view of the moon, and the moon's orbit changes in order for us to see an eclipse.

The 'Earth's shadow' misconception

The most common misconception was that the phases of the moon are caused by the earth casting a shadow onto the moon. Students believed that the earth comes between the sun and moon and blocks or partially blocks the light that falls on to the moon. This does happen occasionally and is called a lunar eclipse, but it does not give the appearance of changing phases.

When asked about the phases of the moon in the pre-test Stephanie and Ian showed evidence of adhering to the 'earth's shadow' misconception.

Q: When we look at the moon in the sky at night, it's often changed shape between a crescent and a full moon, do you know what causes it to look a different shape?

Stephanie: Shadow from the Sun

Q: Shadow from the Sun?

Stephanie: Yeah

Q: What do you think?

Ian: I don't know

Q: If you had to say something, what would you say?

Ian: The shadow, I'm not sure

Q: What's the shadow from? What causes the shadow?

Stephanie: The shadow of the Earth from the Sun

Q: The shadow of the Earth, right, would you agree with that?

Ian: Yeah

Q: You'd agree with anything, wouldn't you! Do you think you can draw a diagram of that, one of you? Who is going to do the drawing? Draw the Earth, Moon and Sun and perhaps draw the Moon where you think it would be as a crescent or something

Ian and Stephanie then drew a diagram that showed the moon as a crescent on the other side of the earth from the sun.

In the pre-test Nills and Sarah also showed their misconception.

Q: And why's that make it change shape?

Nills: It doesn't it's still there

Sarah: Yeah, it's still there whole

Nills: It's just a shadow

Q It's just a shadow?

Nills: Of the Earth

Sarah: mmm

Q: You agree with that do you?

Sarah: Yep

Some students held this misconception after the emirical study. The students' diagrams show clearly the nature of the misconception.

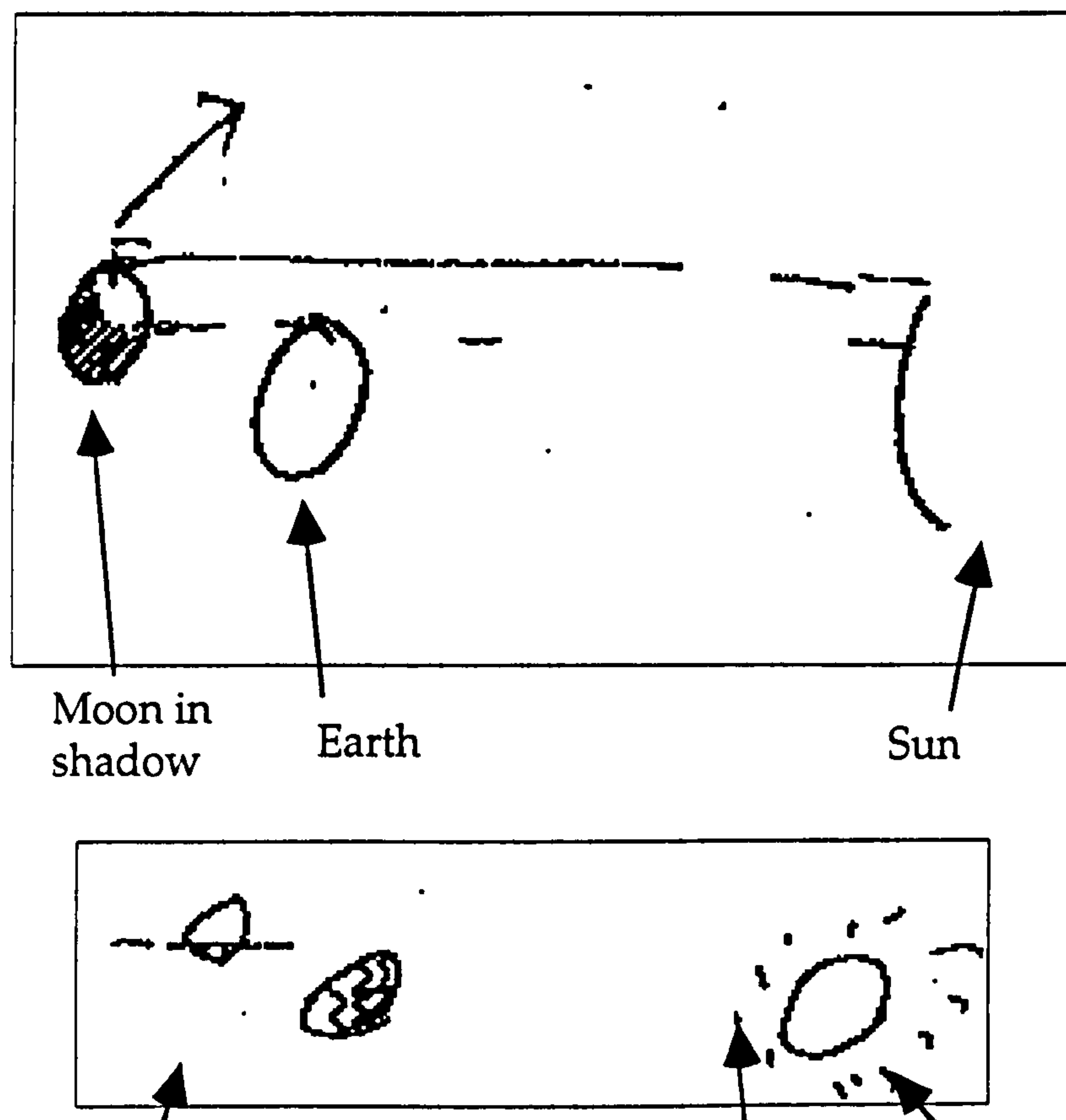


fig 4.2 Two of the students drawings showing the 'shadow' misconception

Four pairs of students out of the ten pairs who did the multimedia versions suggested in the pre-test that something casts a shadow on the moon; two of these pairs still held this belief in the post-test.

The 'blocked view' misconception

A second misconception regarding the moon's changing phases is that they are caused by some object coming in between the earth and the moon and blocking the view of part of the moon. Students have suggested that the sun or part of the earth could do this.

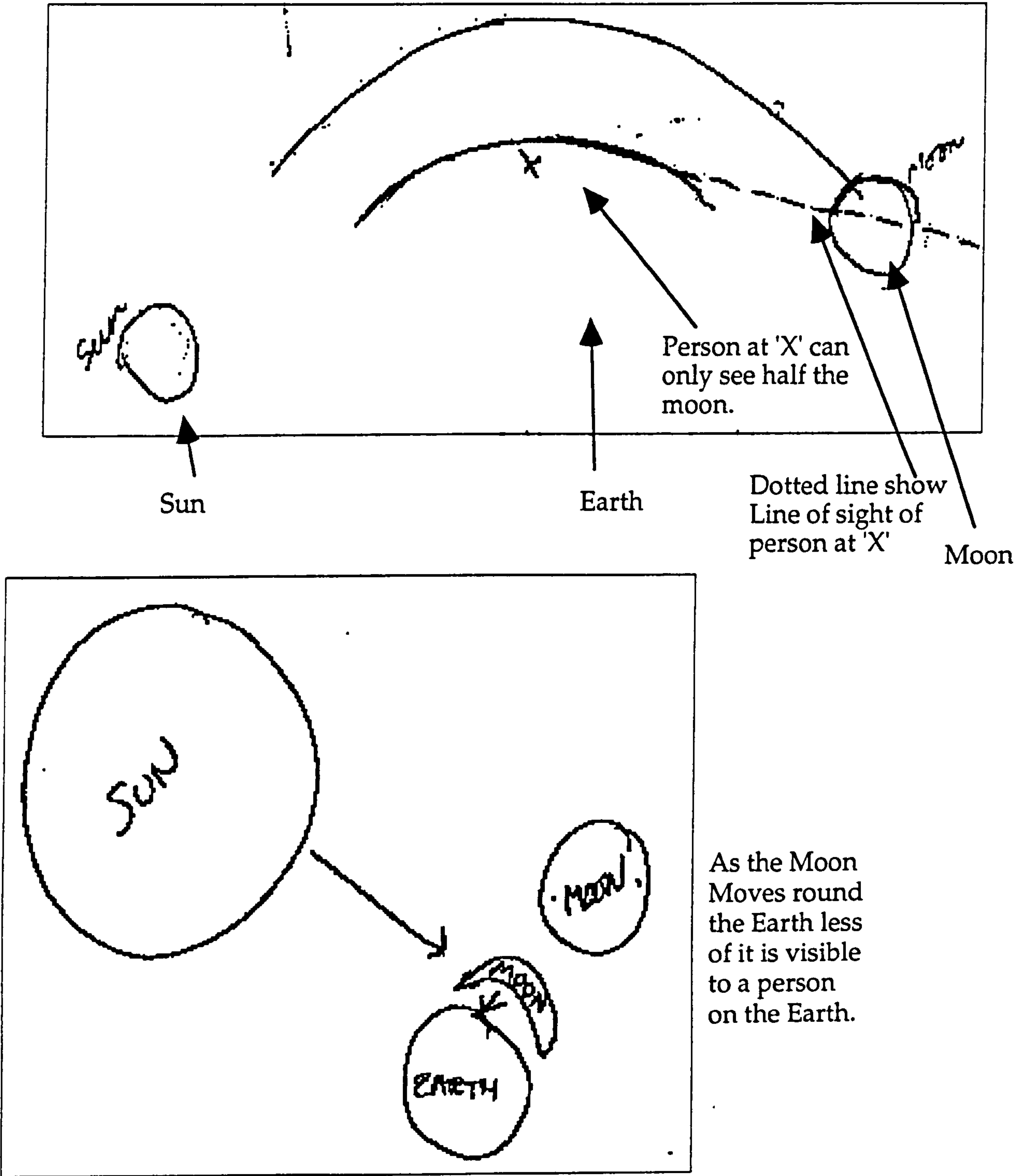


fig 4.3 Two student drawings showing the 'blocking' misconception

Three pairs of students thought that something blocks the view of the earth to make the moon appear as a crescent; two pairs stuck with this misconception for the post-test. Only one

pair of students when asked in the pre-test correctly described what makes the moon change phases.

	Correct	Do not know	Shadow	Blocking
Pre-test	1	2	4	3
Post-test	4	2	2	2

fig 4.4 common misconceptions in pre and post-tests about moon phases

Lunar Eclipse misconceptions

Students were also asked to describe how the moon, sun and earth would be arranged if a lunar eclipse was visible from earth. Students' misconceptions relating to this are that the moon comes between the earth and sun (this is a solar eclipse). When asked, they explained that there is not a lunar eclipse every month because the moon's orbit moves up and down. So when there is a lunar eclipse, it is because the moon's orbit has changed. This explanation does not fit well with the misconception that the earth casts a shadow on the moon, but students were prepared to accept both.

The figure 4.5 below shows how many pairs of students held the common misconceptions. The number of students with misconceptions about the eclipse rose because in the pre-test none of the students knew enough about the phenomenon in order to even maintain a misconception.

	Correct	Do not know	Eclipse misconception
Pre-test	0	10	0
Post-test	2	5	3

fig 4.5 common misconceptions in pre and post-tests about lunar eclipse

When asked to point out on a plan view of the moon's orbit around the earth with the direction of the sun marked, only four pairs out of the ten pairs that completed the multimedia versions could correctly place the moon in the position to show where it would be in its orbit if it appeared as a half moon from earth.

Again there was no discernible difference between students that completed the structured multimedia version and those who did the linear one.

4.4.3. Interaction

Guidelines from Brown (1988) and Chabay and Sherwood's (1992) were followed where possible. These guidelines are many and quite detailed and deal with topics such as:

the importance of keeping the interface simple.

the need for consistency in the positioning controls on the screen and the positioning of similar types of text.

ensuring that the computer feedback reflects the true status of the program.

making any computer dialogue easy to understand.

All user input for the program was through the mouse. At no point did the users need to use the keyboard. Most students had used a mouse in the past, those with no experiences did not have any problem in learning to control the mouse. Interaction and control of the program was made in several different ways. In the structured version the selection of sections was accomplished through menus. The users could decide which routes they would take. Routes that had been exhausted were marked with a tick saying 'read'. Users were still free to go back down these routes as some did.

Navigation through linear sections in both the structured and linear version was achieved by way of arrows at the bottom right hand of the screen. An arrow pointing forward (to the right) meant 'go on to the next page' and an arrow pointing backwards (to the left) meant 'go back a step'. An arrow that pointed backwards, but had a ninety degree turn up in its stem was used to signify a return to the previous section / level. Users used these conventions happily. Many of the users had not used a computer program of this type before. Students who wanted to move on or retrace their steps did so without confusion or problems.

Video clips were presented on screen by showing just the first frame- a short note above the clip read 'click video to play it'. Again students recognised what to do and did so without hesitation. This action on a picture would be new to the learners, but did not represent a problem.

Sequences of stills or short video sections that paused with text displayed beneath them were facilitated using a small forward pointing arrow, much like the play button on a tape player. All of the sequences would loop round to the beginning so that the students, should they require, would be able to go through the section again. When the sequence had reached the end, the forward pointing arrow was replaced by a similar backwards pointing arrow. This successfully indicated the end of the sequence. A few of the sections did not properly implement the backwards facing arrow at the end of the sequence; in these sections the

students would click round to the beginning of the sequence again. In these instances the students easily recognised that the sequence was starting again.

The level of interaction that is described above and which is available to students was simply that of deciding what to do and when. At this level of interaction students were able to control the pace of their learning. The only feedback on students' actions was the simple responses to the users' direct input. For example, a click on the arrow pointing right resulted in the next page being displayed. The type of feedback was not dependent on the achievement of the student, nor did their actions change something in the system that determined the system's feedback. The students' relationship with the program was just that of browsing.

4.4.4. Navigation

Both multimedia programs recorded the time a student spent on a card, which cards were visited and also details of activity on a card such as watching a video or playing a sound. From this data it is possible to reconstruct the students' route through the material.

All the students who worked with the linear version had to work through the cards in sequence. Their only option for changing that sequence was to backtrack or quickly move forward through cards. Only one pair of students deviated from the obvious path and that was to turn back a page since one of the pair had advanced to the next page before the other student was ready. The students turned back a page with little hesitation, indicating that they were aware of the possibility of retracing their path through the material. If other students were similarly aware of this possibility they did not feel the necessity to do so at the time.

The students who worked with the structured multimedia version had greater options for navigating the material. The structure was more explicit as the material was laid out into sections and some sections subdivided further. Students could visit these sections in which order they wished though there was an implicit order in the way that the menu was laid out. Sections that had been read were marked as read, but if they desired, students could easily re-visit these sections.

The lack of an explicit structure in the linear version may have created some confusion, as one pair indicated in their interview after completing the linear version.

Q: What do you think makes you confused?

Andrew: The way it just chops and changes between subjects, it'll be talking about the moon and then it'll be talking about the planets and then about the pendulum

Most student pairs followed the implied order of the material. One pair of students did complete the sections in a different order, working with the section about the moon before

Foucault's pendulum. There was no discussion about how they chose this path, and they had no real explanation for this choice when asked at the end, other than "because we could".

As in the linear version a pair of students turned back a page since they had turned over the next page too soon, again showing that students were well aware of the possibilities of navigation.

In both the linear and structured versions students showed more variation in navigation within a 'page'. On many pages of the program there was either a video window, still pictures, or a sequence (of still or video). The students had the ability to watch the video or go through the sequences as many times as they wanted to. All students repeated at least one of the videos or sequences. Many students repeated several, sometimes more than once.

Rarely was there any spoken negotiation between the pair over what was repeated. When there was it was similar to the extract below.

Pip: Shall we go on - or see it again?

Martin: Do it again.

Conversation while working with the structured version.

There are several reasons why students repeated videos and sequences in either multimedia version. The video may have been repeated due to a novelty effect of seeing video moving on the screen.

Nills: Another video - ooh wicked!

Comment while working with the structured version.

Sequences were also repeated in order that the student could review them. Of course on the second time through a sequence students already knew the point that it put across. The students would be able to have this information in mind as they watched the sequence again and focused their attention on understanding that aspect.

Martin: Did you get that?

Pip: Go through again.

Conversation while working with the structured version.

Simon: "With a video, you know you play it and you take in as much as you can, with that [structured multimedia] you can play about with it."

Comment during the interview.

A third reason why students repeated the video was that the first time through the picture was not clear or detailed enough.

Martin: What happened there?

Pip: Don't know, go on again, see if it's clearer.

Conversation while working with the structured version.

Linz: That's the moon innit? [plays video gain to see]

Comment while working with the linear version.

During the interview it was clear that students realised it was possible to move around as desired in the structured multimedia.

Ian: You can pick what ever one you want instead of being told what to do

Q: So, do you think it's better having control of what you're doing?

Ian: Yeah

Stephanie: Yeah

It was also apparent that the students could see the benefit in reviewing sections that they had not at first understood: when the students were asked to apply what they had just learned from the program in the post-test they realised that they did not sufficiently understand the material and asked if they could re-examine the appropriate section.

Q: Have you any idea at all? What did the programme say about it?

Stephanie: Can I have another look?

Ian: Have another look?

Martin: And then when the roundabout went round the, can't remember what it was called, brings it out as well, as you're going round this was

Pip: Can we go and have a look?

A few minutes later in the same interview....

Q: Okay, that's good. So what does that show about the earth?

Martin: Not sure, can we look at the program again?

[start browsing program again]

When three pairs of students were allowed to return to the structured multimedia program they demonstrated their ability to locate the information that they required.

But while working on the system they lacked the motivation to review sections.

Q: You can go back to things too, you did realise it was possible go back at any point.

Did you feel like you understood everything, and had no need to go back?

Nichola: No

Simon: Just couldn't be bothered

Users were competent in navigation but needed the motivation to navigate the material.

Martin and Pip found extra motivation to explore the material when they found that they needed to answer questions. Simon was not interested in the material and so of course was not interested in doing any more work than was necessary. Perhaps if the programs had engaged the learners more successfully and had set specific tasks to be completed then students would have reviewed sections more often.

4.4.5. Students' Perceptions of Learning from Multimedia

One of the aims of the interview that was carried out after the students completed one of the multimedia versions was to assess students' reactions to working this way and their attitudes to this kind of learning. Almost without exception the students' general attitudes were very positive towards working like this, and their comments are in line with the expected benefits of multimedia - appreciating the control and the interaction that multimedia gives over traditional teaching methods.

The ability to control the sequence and level of learning can have advantages over text and classroom based tuition.

Q: How would you feel if the whole thing was on video like a TV programme. Is this better than that, or...?

Pip: Yes because it can go slower, otherwise you'd have to be stopping and rewinding it all the time. Otherwise if it's there you can read the words on the screen and go back to little bits, like if you read a book, go back and get bits.

Stephanie: No, I think you learn more with this [than with a teacher] because it's more interesting than a teacher just talking to you, making you write things down and stuff, cause you're doing it, more interesting so you learn more

Q: You say you're doing it, which is more interesting, rather than being told it?

Stephanie: Yeah, cause if we was told to just do something, from a book or whatever and we copy it out, draw a picture, or whatever; with this you're like doing it, listening to it and everything and it's easier to understand

The active involvement in the student's own learning is better than the passive involvement in television and video viewing.

Andrew: It's better doing it yourself cause you're learning while you do it, whereas watching video it goes in one ear and out the other. Basically, but this you've got to concentrate, so I think this is a better learning way.

Sarah: [with video] you're not learning yourself, you're just sitting down, plonking yourself in front of the TV and watching it

Sarah: I think this is a better idea because it helps you learn more. If you sit down and watch a video, you get bored with it after a while cause you're not really learning much yourself, just watching somebody else lecture you on it; this way you can. It's the advantages of reading a text book because you've got all the information there; it's also got the advantage of playing on a video, because you've obviously got the video there.

While recognising the problems of control and concentration that can be associated with learning from television and video, the students still acknowledge the benefits of the visual nature of the medium in comparison with a non-visual medium.

Stephanie: Well if you read it then you might not understand what things go and whatever. When you watch it, cause like when it said the pendulum or whatever, the camera was going round you might not understand it. When you watch it you know what it means and it shows you

Martin: it's good [the video]. Instead of just like writing it, we can actually, like, see it.

Andrew: Yes, because you can actually see it, it tells you what to do, then it actually shows you which is like, good cause you get, like a demonstration, what's going on.

4.4.6. Identification of 'Scientific Model' Text

A teaching aim of the original video and of the multimedia versions was to demonstrate how models of systems can be used to investigate the real system and how they enable the researcher to examine the system from a different frame of reference. Models were used in the programme to explain observable phenomena such as the changing phases of the moon and retrograde motion of the planet Mars. By modelling these systems scientists can see clearly how the systems work and when the model does not accurately describe observations they can adjust the model in order to form new hypotheses about the real system. The programme also shows how models allow us to look down into a system from a different frame of reference, and uses the example of Foucault's pendulum to test a hypothesis based on a model to provide real evidence about the earth's rotation.

This 'model' theme links all the sections together, but is not explicit in the original video and therefore neither is it well defined in the multimedia versions. As part of the interview, many of the students were asked to describe the central theme of the video. This question was also part of the written questionnaire that students completed after watching the original video tape.

The quotes below are typical answers from the interviews; none of the students from the multimedia pairs described the program as being about models.

Q: What do you think the programme was about, if you had to sum it up?

Nills: Um, what we see of the solar system

Sarah: What our view is of the moon, Mars, sun, basically the solar system orbiting around the sun and how it appears to us

Michelle: A pendulum!

Andrew: It was about....

Michelle: The earth and the way it works, sort of

Andrew: Say it's about orbits sort of thing, orbits, how things orbit.

Q: Right, what about the pendulum though?

Andrew: That's in a way about it still, cause that's showing how the earth moves on it's axis while it's orbiting the Sun.

Pip: the moon and the earth.

Matthew: Axis and what the earth, how it revolved around the sun and kind of things you seen why would it happen

Pip: That the earth's rotating?

Matthew: Um, not sure. Just showing, more like explaining what happens about the moon and the earth, why the moon goes round the earth.

Ian: Space.

The responses on the questionnaires of students who saw the original linear video were the same. Only two of the twenty six students did name models as being what the programme was about:

"About using models in science, so you can see things from a different vantage point"

"Using models in science"

Whether the students had identified models as being the central theme which tied the examples together and not the examples themselves is perhaps not important - indeed video and film often deals with a topic in this way.

Why did so many students fail to realise that the main learning aim of the programme was the use of models and viewing from a different frame of reference?

From her study of how learning relates to the structure of a video programme, Laurillard (1991) finds that the structure of a programme relates to the identification of the main point of the programme.

If the programme has a more explicit focus on the point of the programme either by restatement of the main point or by the use of examples that directly illustrate the main point then more learners are able to interpret the programme in terms of the main point. If instead the focus of the programme is on examining the component points of the argument and the examples to these points (rather than examples of the main point), the learner is more likely to interpret the programme in terms of the component points and examples, rather than the main point.

This was certainly the case in both the multimedia programs and the original video programme. Compounding the problem was the theme of the programme in which the examples chosen were all about our viewpoint on earth. It would have been easy to pick different examples that illustrated the need for models and different viewpoints, examples that did not relate to each other apart from the fact that they illustrate the programme's main point. The common theme of the programme would be the main point in that case. From the examples picked, it is easy to see how the students identified the common ground between the examples as the main point instead of the intended main point.

Laurillard (1991) also suggests that the confusion of the main point may be due to the learner assuming a linear rather than a hierarchical structure to a programme. If the learner is unaware of the cues that point to the hierarchical structure of a programme then they may well be unaware of the structure of the programme's argument and how the main point, component points and examples relate.

The structured multimedia version explicitly revealed the structure of the program, but the analysis did not record a better identification of the program's main point. This is probably because even though the structure was more easily perceived there was still no restatement of the main point, and too much concentration on component points and their examples.

Even if the students did not correctly identify the goal of the program, maybe they still learnt it through the examples. When asked 'What do you think the benefits of using a model in science are?' in the pre-test all pairs described the benefits either as being able to see something that would not otherwise be visible, or talked about their use as teaching aids much like a diagram.

David: Well, yeah, I'm just looking in there and seeing a skeleton [in the classroom]
We wouldn't be able to see the ones things like that, just give you an idea of what it looks like because we can't see the planets with the normal eye, so if we've got a model to show the distance it gives us a fair idea of how far away we are from the planets.

Stephanie: Easier to understand, better than just saying, cause you get to see a picture of it and that

Ian: Better than looking at books

Stephanie: More interesting

Answers to pre-test question.

Post-test answers to the same question also talked about the visual and teaching aspects, but with the addition of two new types of answer: models are not reliable unless they are accurate; models can be examined and adjusted to learn something new.

The video had shown that by building a model of a system, then testing that model to see if all real observations can be explained -that if the model could not explain an observed phenomenon in the real world then this might show that your understanding of the real system is not good enough. By adjusting your model accordingly it is possible to come to a new understanding of the real world set-up.

Some students realised that the program had shown that models are sometimes inaccurate, but they had not understood that this is a feature and not a fault. As this section from a post-test shows Stephanie and Ian had thought the program warned against models.

Q: What do you think are the benefits are of using a model in science?

Stephanie: If the model was accurate it would help you understand

Q: So, you can't rely on models, is that what you're saying?

Stephanie: Yeah

Ian: Not all models

Q: Are there any benefits in that?

Stephanie: In what?

Q: In models which don't work. Is there something good about that or is it just plainly bad?

Stephanie: No, cause it doesn't tell you what's right and it might just tell you one side of it, whatever

Q: There was a problem with the model we used in the studio, of the planets, of the Moon and the Earth, can you remember what the problem was?

Ian: They had to move the Moon up

Stephanie: Wasn't so accurate

Q: So, do you think it's useful using models or do you think it's better to stay clear of them?

Stephanie: If you know what you're doing with them, it's all right

Q: So, what uses would the models have in science? Can you name a couple of uses?

Stephanie: You get to actually do it yourself, so it's not so boring, so you might take it in easier and understand it

Q: Uh, huh, can you think of another reason, Ian?

Ian: No

Nills and Sarah had a similar problem in the post-test

Q: Right, good. Finally, what do you think are the benefits of using a model in science?

Sarah: As long as it's accurate and it's...

Nills: Accurate

Sarah: Yeah and you've got everything set up in the right way it should work

Nills: You can see what's going on

Sarah: Unless you've got it completely accurate, then...

Nills: No point in doing it

Sarah: There's going to be no point in doing it because you won't be able to

In total three pairs of students had this misinterpretation.

Three pairs of students interpreted the use of models much more positively, as the program intended.

Q: What do you think the benefits of using a model in science?

Pip: It explains things, you see it more

Matthew: Yeah

Pip: You can relate it to the various things, if you think logically, but I don't so....

Matthew: It's like you can actually see, instead of, like somebody just talking to you then, you can actually... well, if someone was talking and you could see something then you'd like know what it was and how it moves.

Q: Is there more to it than that?

Pip: You can form theories on it and query things and stuff

Nills: There is a point in having an inaccurate model. If you don't know what you're looking for in the first place, if you get something completely wrong then you learn from you're mistakes

The students who thought that the program showed them that models can be inaccurate and should only be used carefully had only come halfway in the argument.

The pre-test question about the benefits of models which was asked in the questionnaire that students completed before the watching the original video elicited answers mainly about models being useful as visual aids as in the pre-tests before the multimedia version. The post-test answers were very similar to these pre-test answers. In fact many post-test answers were shorter and less detailed, though this is probably due to the written nature of the test, and that they had little more to add to what they had said in the pre-test.

4.4.7. Learning Gains

A measure and comparison of learning gains between the three conditions was not an aim of the study. Of more interest were types of learner problems and approach to each condition. A

comparison of learning outcome would have been a useful addition to the data collected, and was attempted to a certain degree, but suffered because of the reasons described below.

Foucault's pendulum and the retrograde motion of the planet Mars, were both completely new to the students. Since these areas were completely new to the students it was not possible to ask questions about them in the pre-test. The students did have an understanding of the basic principles of the solar system so it was possible to ask students about the reason for the moon's changing phases in the pre-test, though none showed an understanding of this.

The teaching aim of the original programme was to demonstrate how it is possible to better understand a system by looking at it from a different frame of reference, and to show how models can be used to do this. While learners were expected to come away with an understanding of the examples used, the primary purpose of the programme was for the students to learn the importance of models in explaining and understanding observed phenomena, in order to gain this perspective an understanding of the three examples is necessary.

Assessing the learning gain is difficult since it was hoped that the learner would see the need to look at a problem from a different frame of reference and have an increased appreciation of the use of models. Such learning is not easy to measure, especially given the small numbers in the study.

It may be possible, however, to look at how the students' understanding of the specific models changed, though still the size of the groups involved makes this difficult too. However, a more important factor is that the nature of the examples makes determining the students understanding of them difficult. The video was selected since it dealt with an area which was difficult to show in other ways as it involved understanding the relationships between moving bodies over time. The video may have supplanted cognitive processes in order to bring the learner to a particular point of understanding. If this is the case students may not be conscious of a full description of how the example works, but still understand the outcome. Also the 3d visual movement the video shows is not easily described by the student in words or writing in the post-test, even explaining by using drawings is tricky. These difficulties were evident when watching the students explain their post-test answers. For example one student could show how the retrograde motion of Mars worked by using his pencil to show the line of sight and then moving it to show the movement of the planets, but could not offer any spoken or written description of the process. Other students were equally unable to describe the process, but it seemed that they did not understand it at all.

Because of this type of vagueness, many of the student's answers to the multimedia pre and post-test questions could not be categorised as either correct or incorrect, or even graded

according to how correct they were. This level of uncertainly in grading does show that some parts of the program were not understood by any of the students.

Below is a summary of how much of the multimedia programs the students understood:

Half of the pairs of students understood why the pendulum on the roundabout looked as if it swung strangely, but only two pairs realised the connection between the pendulum on the roundabout and the one in the cathedral. Three pairs understood that the pendulum in the cathedral demonstrated that the Earth rotates.

Few students sufficiently understood the reason that the moon changes phase. The student's achievement in understanding the phases of the moon and lunar eclipse is discussed in the section on misconceptions.

No students were able to adequately describe the retrograde motion of the planet Mars.

There was no difference in outcome between students that worked with the linear version, or those that worked with the structured version.

The pre and post-test questions completed by the students who watched the original video taped version were scored. A number of marks were awarded out of the possible total for each question depending on how fully they were able to answer the question. Such marking suffered from the problems discussed above, but does give an indication of the students understanding of the examples.

The students that had already completed one of the computerised versions did no better in the pre-test or in the post-test than other students who saw the video. The pre and post-test was marked out of 18, the average increase in post-test score being one (6%). If we disregard those students who had a negative gain the average increase is 2 points (13%)

Pre-test Mean Score	Post-test Mean Score	Mean Gain
3.85	4.85	1.00
21%	27%	6%

fig 4.6 Pre and Post-test results from the video group

The learners' problems with the example matched those of students that had completed the multimedia version in that around half understood the pendulum section, there were similar misconceptions about the moon section, and very few students did well on the retrograde motion question.

4.4.8. Students' Approaches and Attitudes Towards the Original Video

Twenty five students saw the original video. Of those, 2 had already worked with the linear multimedia version and 4 the structured version. All the students watched the video together as a class.

The students were fairly quiet as they watched the video, though this does not necessarily show a particularly high level of concentration. Perhaps their level of engagement with the material was revealed by the fact that they found some parts of the video amusing. Rather than being absorbed by the video's content they found it necessary to find enjoyment in other elements of the video. They found the 'typical' Open University academic's appearance and voice amusing, and during the scene in the cathedral many were willing the large pendulum to hit the presenter rather than missing narrowly as it did.

The questionnaire analysis further elaborates the students' attitudes. Of the 14 students who suggested what changes they would make to the programme (question 8) six students criticised the style of the programme; that it was not up to date, the presenters were directly criticised. The programme was first broadcast in 1988, so while not newly produced, it was not particularly dated either. The comments probably reflect something about the student's expectations of video and television, and that they are used to documentary that is either specifically aimed at them, or at a wide viewing base of national TV. The Open University video was aimed at new technology undergraduates.

Nine out of 14 respondents on question 8 thought that the programme was too complicated, either wanting the programme to be explained more fully, or simpler examples or language to be used. An examination of the script shows that there was no jargon, or particularly scientific terminology used. The programme since it was introducing a way of looking at things rather than any scientific information, did not rely on any previous knowledge. The difficulty understanding the programme is more likely to have come from the complexity of the concepts involved and the speed in which they are dealt with. As one of the students who had already worked with the computerised version observed:

The TV programme was a lot less interesting then the computer program because when you use the computer you can go through it at your own pace making it easier to understand.

In other words, the user control that the multimedia adds makes the topic more interesting because it is easier to understand since it is possible to control your pace. Three of the nine students, who thought that the video was too complex, suggested that the programme should have been slower.

Students would have perhaps have paid more attention to the video if they had been made to watch it in pairs and had the experimenter sitting behind them as was the case with the

multimedia versions. Students also had a clearer idea of what to focus on in the video from answering the pre-test.

The questionnaire also asked some more general questions about the video. Asked what they liked about the programme ten of the students mentioned the use of models, eleven students said they found it informative or enjoyed seeing things from different viewpoints. When asked what the programme was about 23 said it was about the moon, space or planets, two students said it was about using models in science.

When asked to mark as scale of 1 to 10 showing whether they felt like they knew what they were doing (10 being 'yes fully') the average response was 6.2. When asked to mark if they felt they understood enough of the programme the response was 6.9. And when asked if this was a good way of learning the students marked an average of 6.3 out of ten.

The students that had already seen the computerised version much preferred the computerised version saying it was easier to understand more interesting and up to date

Students who watched the video found it difficult to follow and understand, the extra control over the multimedia allows students to proceed at their own pace, and not let information slip past when concentration is lapses.

4.5. Conclusions

The analysis of the original video using Koumi's framework of educational television screen writing, showed how complex the construction of an apparently simple sequence of television can be. The complexity of the language of video can be seen also in the nature of the issues raised during the conversion of the multimedia. The types of consideration found indicate the need and the existence of a grammar of multimedia similar to the grammars of other media, this idea is discussed more fully in Chapter 6.

The conversion of the original video to multimedia kept the original pedagogical structure of the video intact. The multimedia versions suffered from similar problems to the original video, such as lack of student engagement with the subject matter and common misconceptions. There was also no change in learning gain between the three conditions.

The video was not able to offer any kind of user interaction, or feedback on student actions - though it does benefit from its audio visual richness, story telling capability and ability to supplant some of the user's learning experience. The multimedia versions included the video visual element, but lost some of the narrative construction of the video.

The linear multimedia version did not capitalise on any of the interactive potential of multimedia but added an element of user control. This set-up lost much of the video's strength of narrative construction, but added little in return.

The structured version while making the structure of the program more explicit, and giving the user more information about their progress, was still the same pedagogically as the linear version.

In all versions the students' involvement was superficial. The learners were able to navigate the programs competently, and demonstrated that they were aware of how to browse and review the material. However few students made use of this opportunity even when they were aware that they had not understood the program sufficiently.

Giving students the ability to control the pace of their work, or even a full set of multimedia tools and instant access to all parts of the text did not necessarily enable the students to gain any more than they could have from the tape based version. The multimedia versions in fact had not added anything more to the tape based version than user control over the pace and sequence of the material. This was part of the deliberate design aim for the programs. The multimedia version was free from the restrictions of video linearity, but had not taken advantage of the added possibilities open to this new medium. Thus the study demonstrates that simply re-packaging the material in a more accessible way, or changing the medium will not necessarily improve its effectiveness.

If educational material in multimedia is to be as effective as possible educators must design the pedagogy of the material to take advantage of the strengths of a medium. At present, many of the multimedia applications being produced do little more than transfer existing media into multimedia with little change in their design. Following the results of this study we can see that this approach is unlikely to promote better learning than traditional media. The next chapter details the next phase of the study which attempts to exploit the media better with a multimedia program that is designed to be fully interactive and so engage the learners in the material. The program should directly address the misconceptions of learners and focus the learners' attention on the learning aim of the program.

Chapter 5: Main Study: Phase 2

5.1. Redesign of the Multimedia Program

5.1.1. New Design Motivation

Phase 1 highlighted a number of design issues relating to the difference between material designed for the linear medium of video and material designed for interactive multimedia. These form general design points for multimedia. The different versions were not fully effective for learners, in the ways defined at the end of the last chapter. A second empirical study was created in order to investigate how a multimedia program might address these issues of goal oriented learning, intrinsic feedback and greater interaction. It addressed common misconceptions and investigated how they influence the program's effectiveness. There were several changes in the design.

Firstly, Phase 1 drew attention to the need for defined goals to direct the students' learning effort. The students need to be aware of the required outcome so that they can direct their efforts to a specific aim, rather than being concerned that they may be doing the wrong thing.

Secondly, misconceptions hindered student progress in the first phase one. Many students shared the same misconceptions, and so these are specifically addressed by the second phase.

Thirdly, interaction with the programs in Phase 1 was only to the extent of the user deciding when to move on and to where. The program in this phase increases the possibilities for user interaction and involvement. It is hoped that the greater user interaction will result in more enthusiasm and engagement with the courseware instead of the distinct lack of motivation and enthusiasm noted during Phase 1.

Finally, intrinsic feedback was missing from the programs in phase one. As discussed in chapter two, feedback is central to interaction since without it users are not able to learn from their actions. Properly designed feedback should be able to give learners the correct information so that they can adjust their actions in line with their learning aims and strategies. Used in this way feedback can be designed to guide the learner towards desirable conclusions or actions. This new study phase investigates the benefits of providing meaningful feedback on the students' actions.

The following section first looks in detail at the design of a new program and then explains the set-up of Phase 2 of this empirical study.

5.2. Empirical Approach

5.2.1. Program Description

Rather than attempting to show the benefits of looking at a system from a different frame of reference and teaching the use of scientific models, the program takes one section of the previous programme from the last chapter.

The chosen section is that which aims to teach the students why the moon changes phases and enables them to predict how the moon would look from earth at different times in the lunar month. This section was selected since many of the students had problems understanding it in Phase 1. In order to understand how the phases of the moon change the learner is required to follow the movement of the moon and earth in three dimensions and over time.

The program falls into three distinct sections. The first section, 'About the Moon', takes the students through a series of screens that explain why the moon appears as a crescent. The second section, 'Task 1', allows the students to watch the system in action and sets them simple tasks in order to get them to look at and consider the system more fully. In the third section, in 'Task 2', the students are given a view of the moon and are required to position the moon correctly at a point on its orbit in order that an observer from earth would see the given view.

Each section is accessed through a contents menu (fig5.1) which contains branches to the instructions to the task.

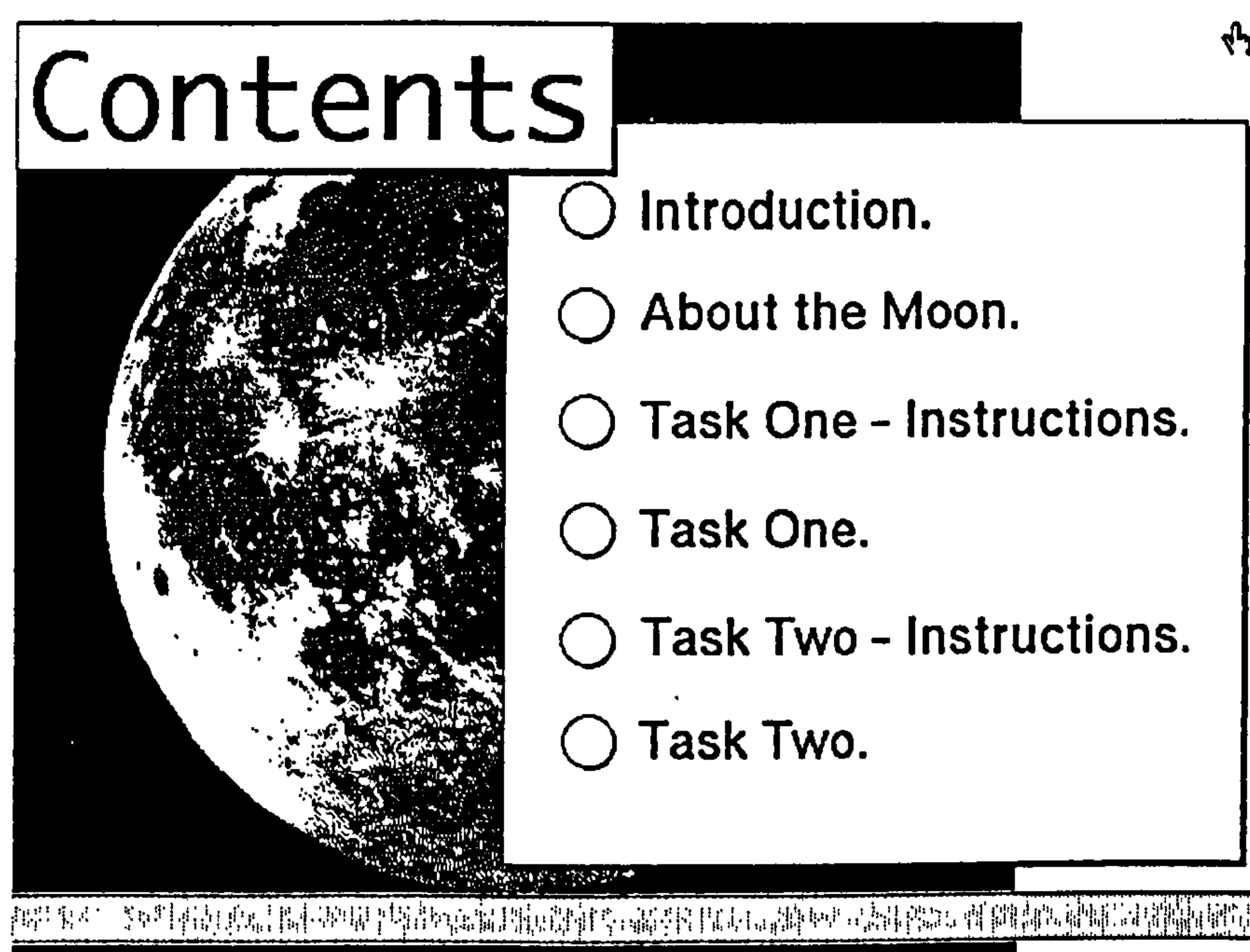


fig 5.1 The Contents Menu

The sections below explain the function and design considerations for each part of the program.

About the Moon

The 'About the Moon' section takes the learner through six pages similar to those in figure 5.2. This section contains all the information that the students need to 'know' in order to understand the changing moon phases. The section introduces the information that they need in order to work with the tasks. Students could also refer to this section later if they had a problem understanding either of the tasks.

The tasks give the students the opportunity to find how well they have understood this and to practice and develop a full understanding and feel of it. Students are able to return to this section through the contents page should they want to.

CARD ONE

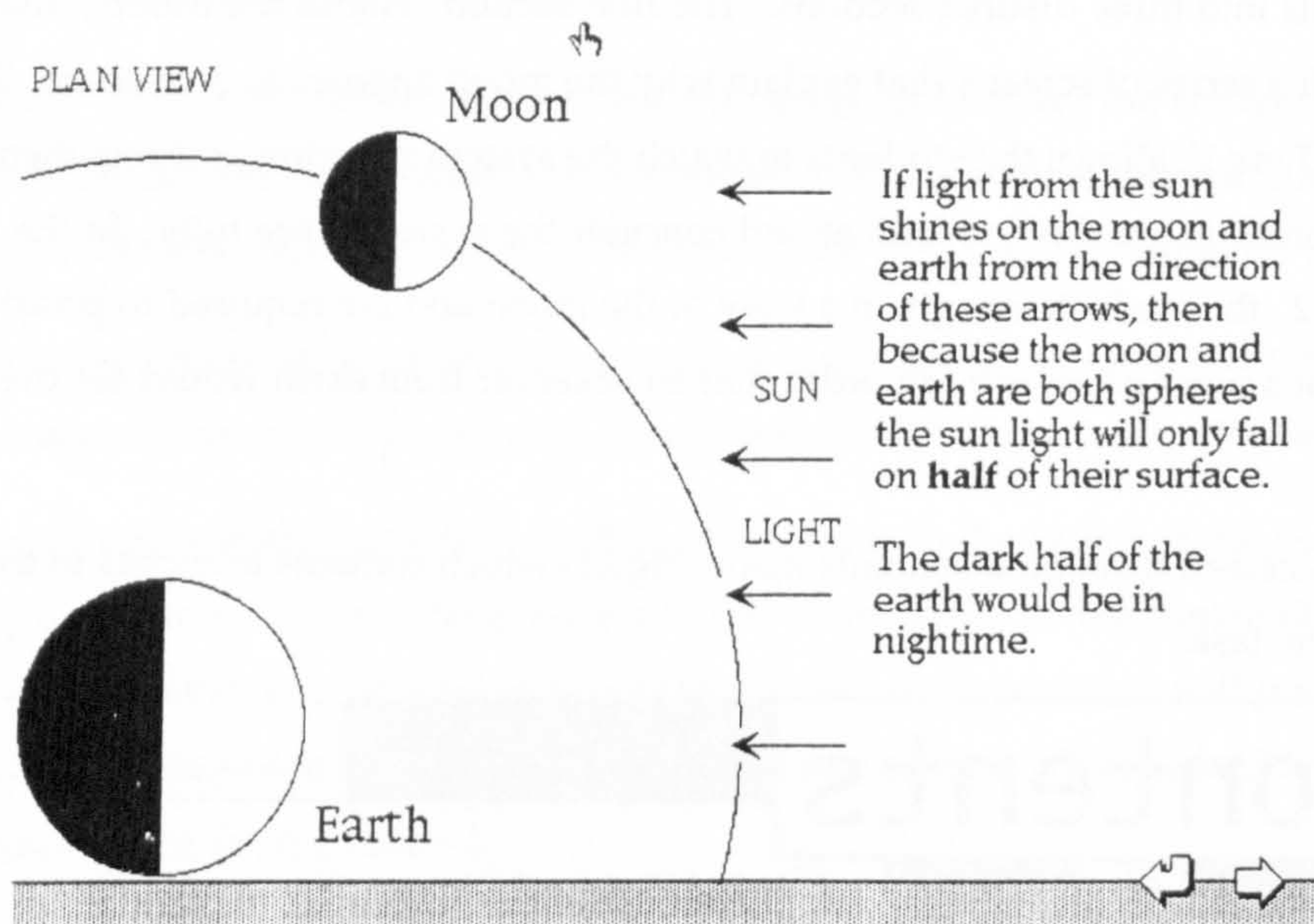


fig 5.2 "About the Moon" card 1

The first card (fig 5.2) sets up the screen layout to be used and clearly shows why one half of the moon and earth are dark, and the other half light. The original programme did not show this, perhaps assuming such knowledge. If this is the case for the users of the multimedia they can quickly pass over this card.

CARD TWO

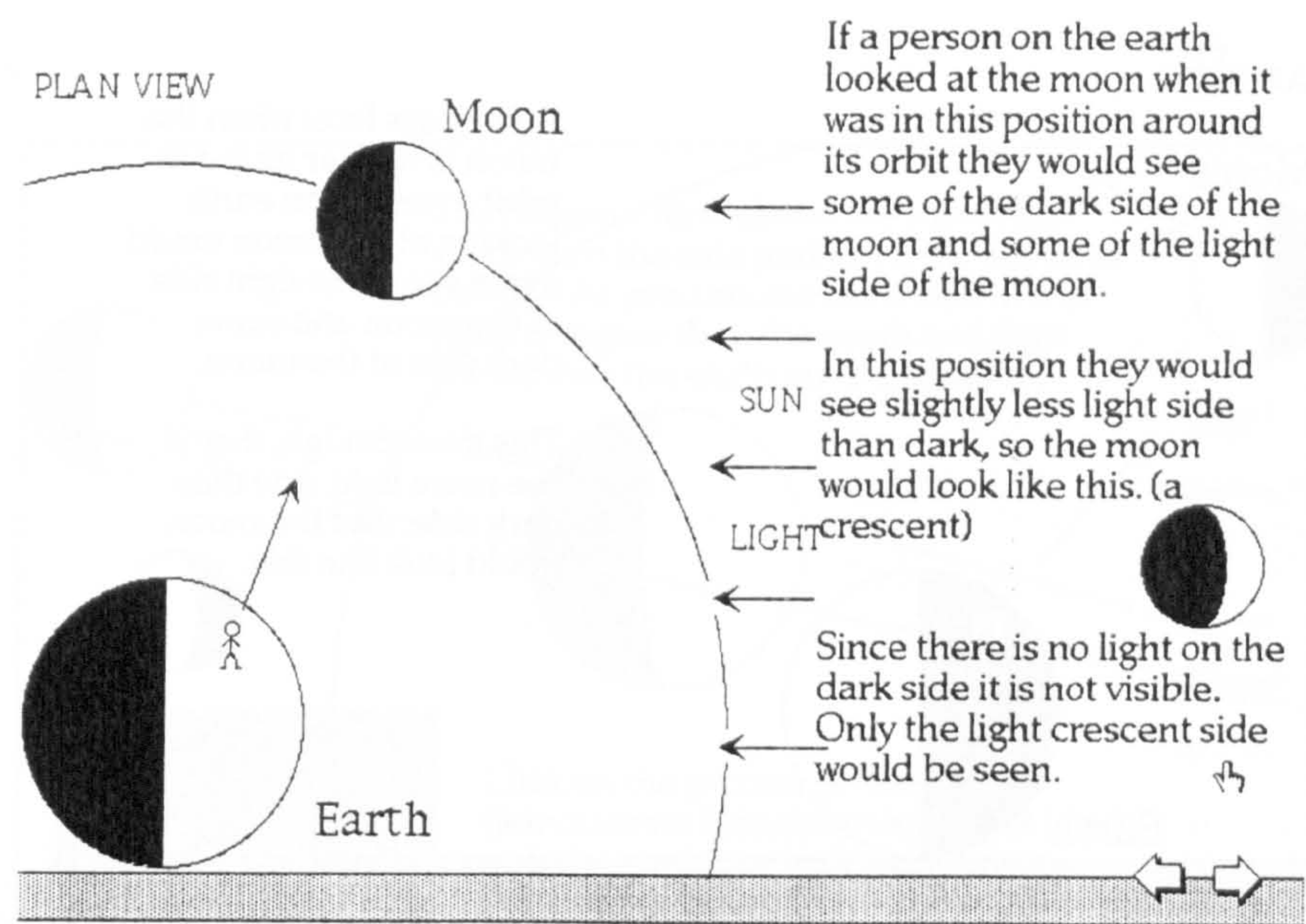


fig 5.3 "About the Moon" card 2

This card (figure 5.3) introduces a person on the planet and considers their point of view. The description describes how much of the light and dark side of the moon an observer would see, as well as displaying an arrow that shows the line of sight and an inset picture of what the moon would look like. It was hoped that the three different representations displayed at once would give the learners more information from which they could understand the view.

The original video did show the point of view of someone from earth by placing a camera in their model earth. Instead of using a plan view as above, they used a view angled from just above the sun and considered the path of light from the sun, rather than emphasising the point of view of the person on the earth. The original programme used a sequence of moon positions, each time the moon moving by twenty degrees. The angle between the sun, earth and moon is hard to envisage, especially viewed from the direction of the sun. A plan view makes the relationship of the bodies much clearer. Perhaps a plan view was not used in the original programme since it would have been unfeasible to suspend a camera above the large model they had built.

CARD THREE

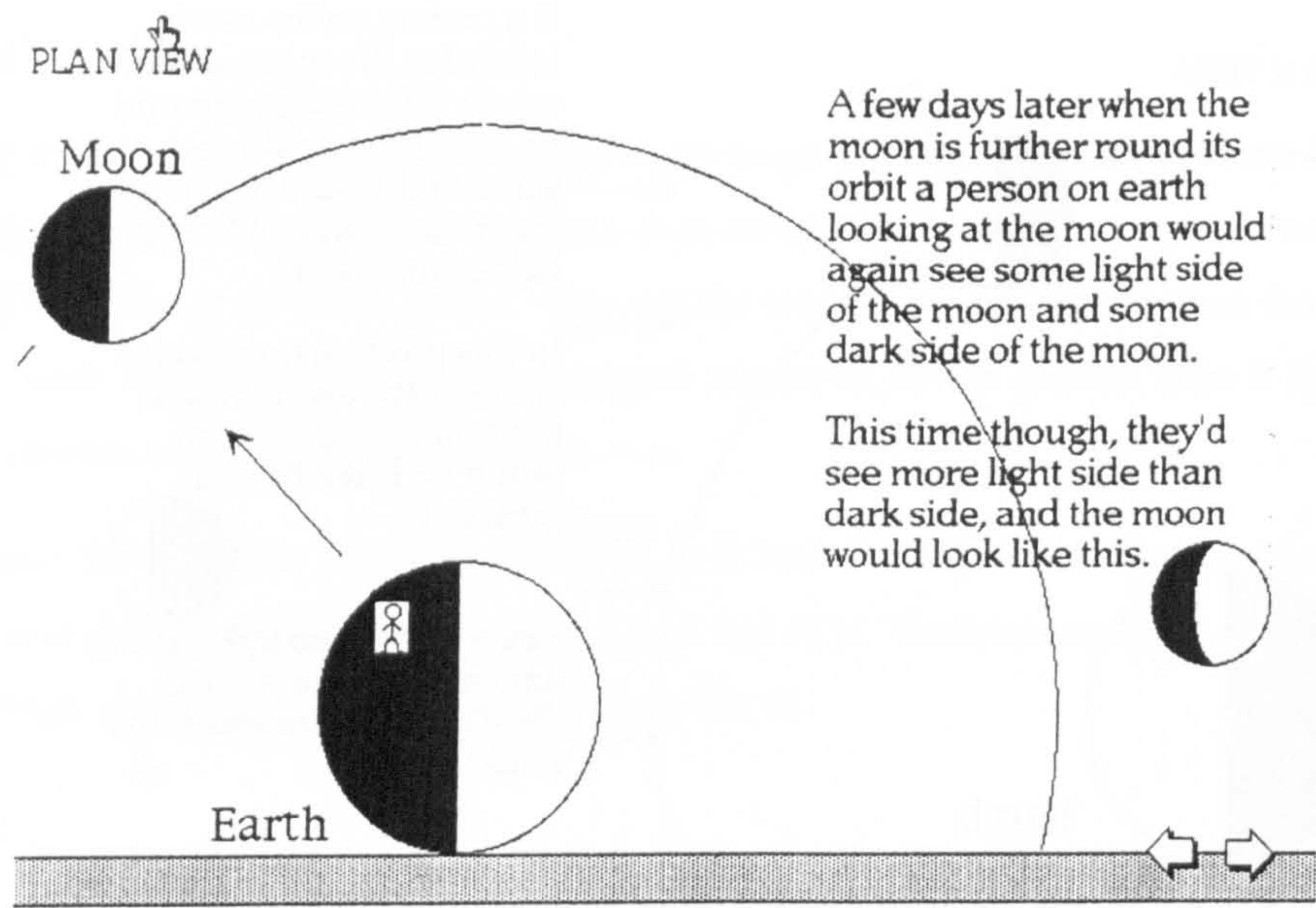


fig 5.4 "About the Moon" card 3

The third card is the same as the second except that the moon has moved round its orbit a little further. This time more of the light side of the moon is visible.

CARD FOUR

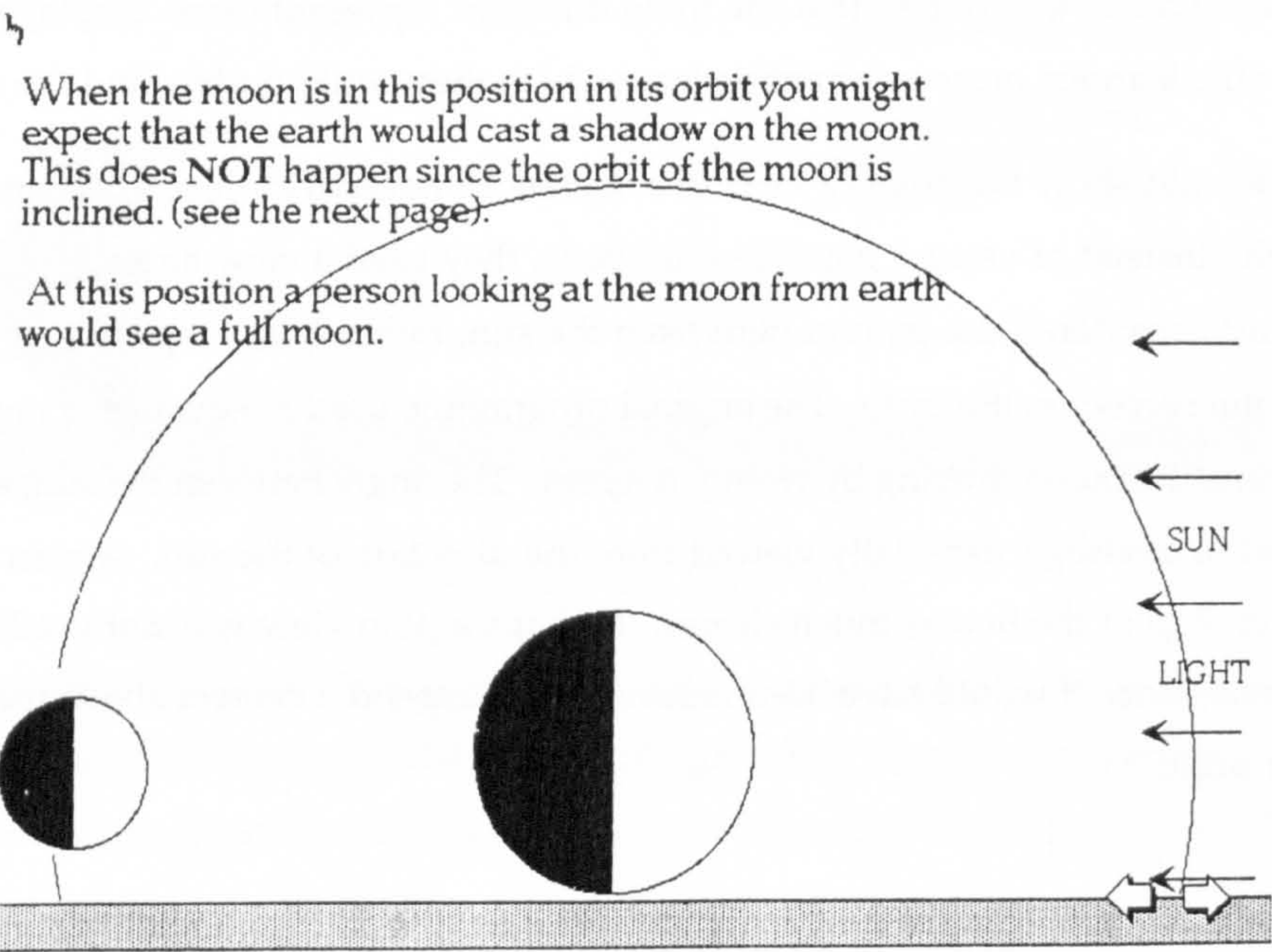


fig 5.5 "About the Moon" card 4

The fourth card shows the moon in the full moon position. At this position many of the students, quite understandably, suspected that the moon would be eclipsed by the earth.

They are given a short explanation why this is not the case, and are asked to look at the next card for a fuller explanation.

CARD FIVE

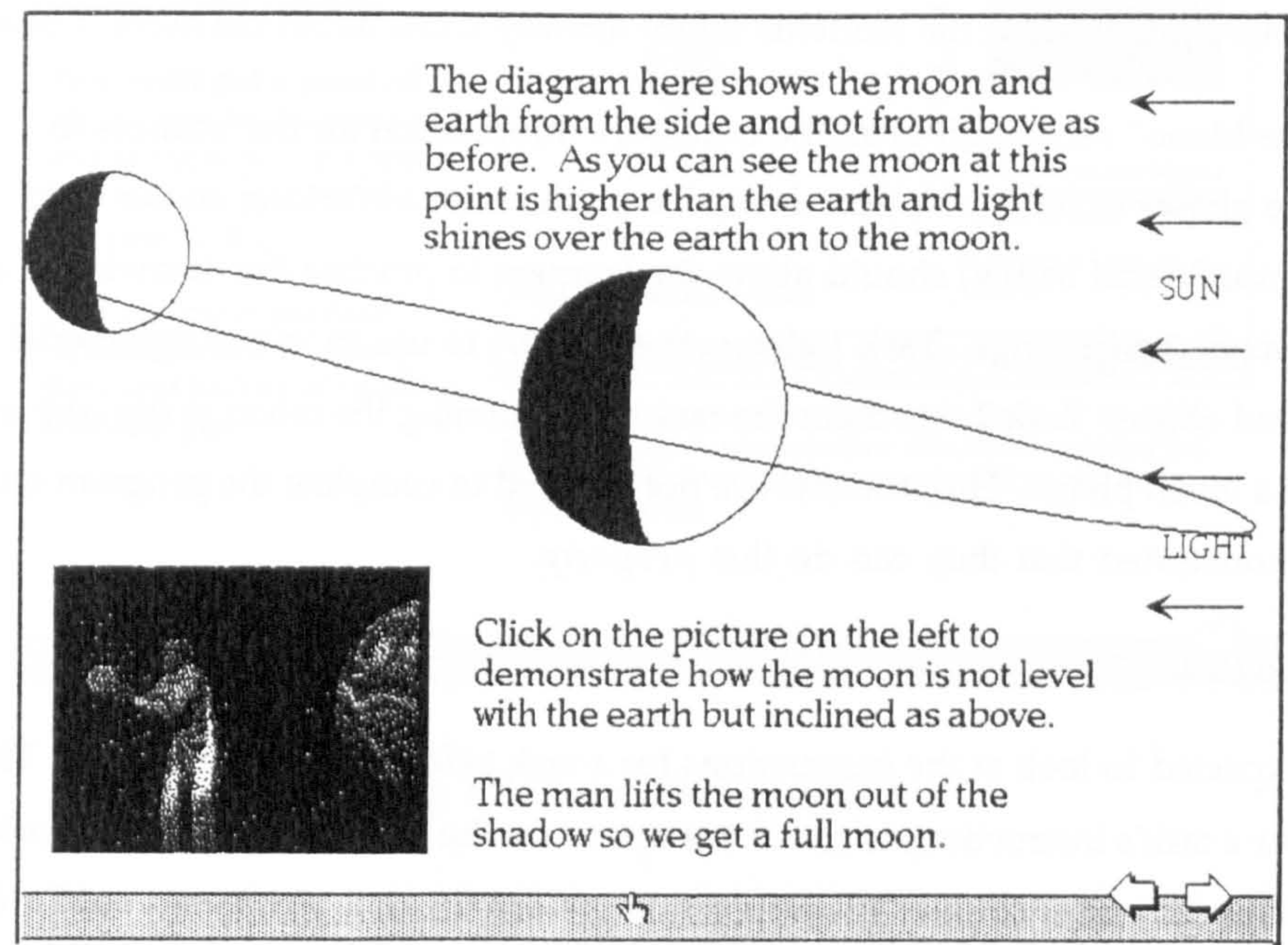


fig 5.6 "About the Moon" card 5

This card shows the moon and earth from the side to show why the earth's shadow does not eclipse the moon at this position in its orbit. A video section from the original video shows a person lifting the moon up from out of the earth's shadow into sunlight to emphasize the point. This video clip was selected due to its positive effect in the previous phase.

CARD SIX

The moon takes 28 days to go through all of its phases.

The phases themselves are visible at different times of the day.

Each day the phase and the time that you see the moon will have changed slightly.

LUNAR PHASE	TIME WHEN VISIBLE
New Moon	During the day, near the sun
Waxing Crescent	Most of the day and early evening
First Quarter	Afternoon and first half of the night
Waxing Gibbous	Evening and most of the night
Full Moon	All night
Waning Gibbous	Most of the night and early morning
Last Quarter	Second half of the night and morning
Waning Crescent	Before sunrise and most of the day
New Moon	During the day, near the sun

fig 5.7 "About the Moon" card 6

The last card finishes the sequence by showing all the phases of the moon and giving them their names. This information is not necessary for completion of the tasks, but it does help to link the previous cards to what the students might already know about the moon's phases.

The "About the Moon" section gives all the necessary information for the learners to understand the phases of the moon, and to work with the tasks. Working on the tasks (described in more detail below) should allow the learners to practise this knowledge and iron out any misunderstandings. Task 1 allows the learners to use an interactive model of the system described above. Task 2 sets them the task of positioning the moon at the correct point on its orbit for a given phase. The students are not allowed to complete the program until they have demonstrated that they can do this properly.

Task instructions

Students are expected to look at the instructions for a task before they work with it. The menu option for a task's instructions is above the option for the task. Students who work down the menu list in order will encounter the instructions before the task. Students could always enter the task before reading the instructions, but to do so would mean that they probably would not understand the task fully.

The instruction page outlines the students' aims and introduces the controls for the task. The page contains a picture of the task screen to further help the learner understand the instructions. (fig 5.8). The instructions to Task 1 are followed by an animation that aims to help students visualise the relationship between plan and side views of the moon's orbit of the earth. The student clicks on the 'changeview' button and the animation smoothly moves from one viewpoint to the other. The smooth change over is to avoid cutting between two views where the relationship over the cut may not be clear. The equivalent camera motion for video would be to elevate, track and tilt. The ability to recognise the relationship of these views is central to understanding Task 1.

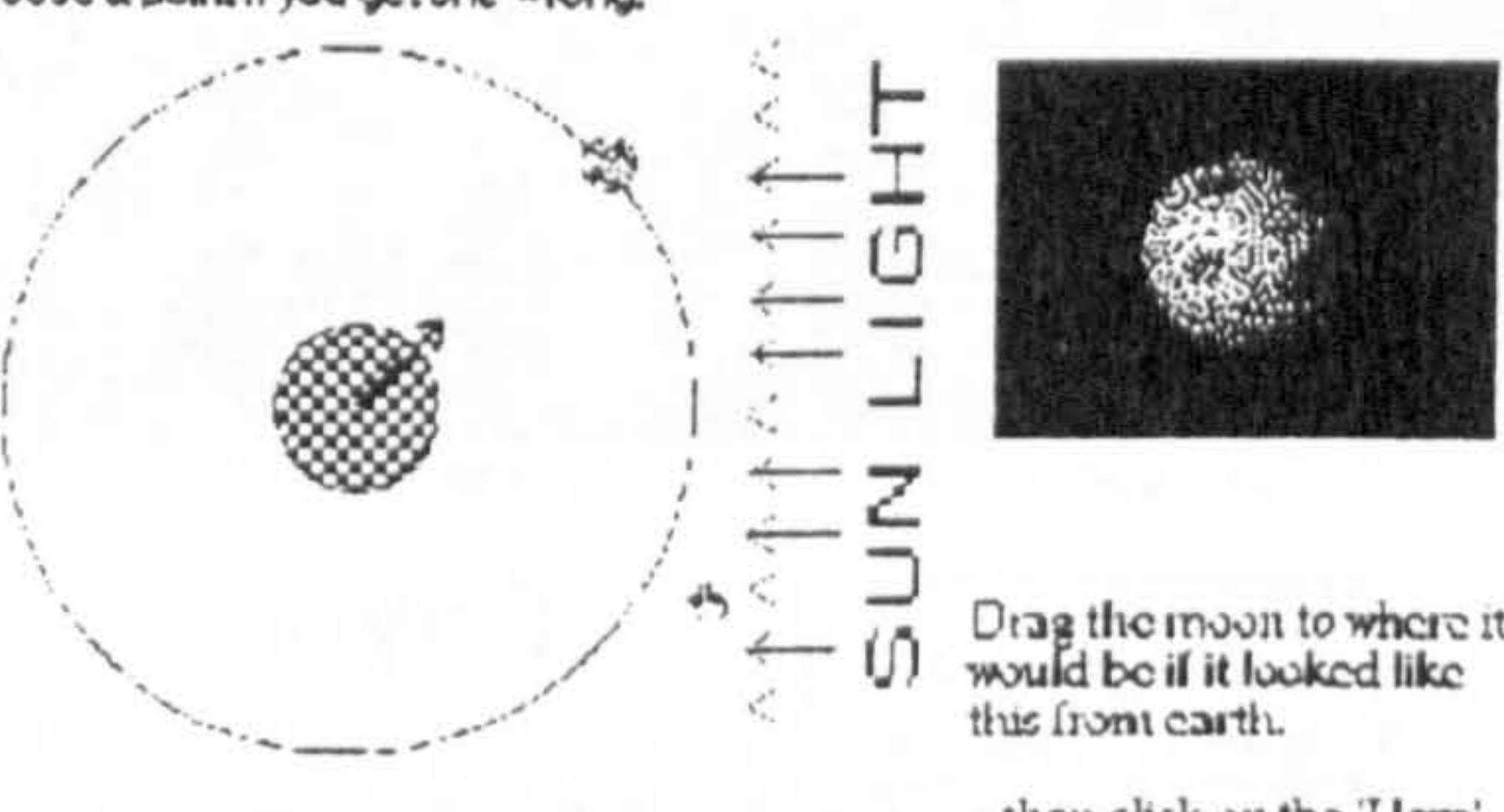
This time you must place the moon on its orbit so that a person on earth would see the moon as shown in the picture.

You must get a score of FIVE. For each correct answer you get one point. You lose a point if you get one wrong.

Don't worry if you have difficulties at first. Going back and looking at task one will help you.

You need a score of 5 to finish. You get a point for a correct answer, but lose a point if you get one wrong.

Try to get your score of five in as few goes as possible.



Drag the moon to where it would be if it looked like this from earth.
- then click on the 'Here' button.

You need a score of 5 to finish.

51 0 Here Go on Look at task one again

During the task you can drag the little picture of the moon by positioning the mouse pointer over it then pressing the mouse button down and keep it pressed down while you move the mouse.

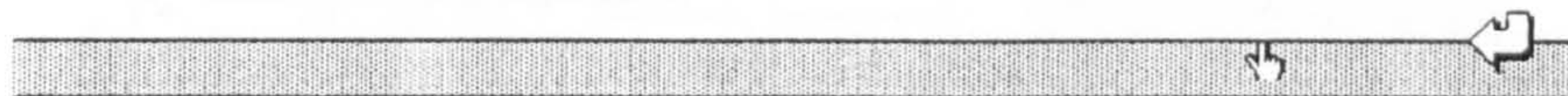


fig 5.8, Instructions to Task 2

Task 1

Task 1 aims to show students the relationship between how the moon appears from earth and the position of the moon around its orbit in relation to the sun. The three video windows in figure 5.9 show the moon's orbit from above, and from the side, and also the view of the moon from earth's point of view. The windows are synchronised so that for any point in the lunar month the student has 3 different viewpoints. The animation may be stepped through a day at a time, or run and stopped with the controls beneath it. In Phase 1 the learner was only able to watch a predefined sequence of the moon in its orbit. This sequence was only seen from one angle. In the multimedia version they can step through the five steps in the sequence. The original sequence did not allow the learner to get a feel for the movement of the moon, see the moon travel round its entire orbit, or see the movement from different perspectives. The interactive model in Task 1 allows the user all of this freedom, while setting questions to be answered to ensure that the activity is one of interaction and engagement rather than browsing.

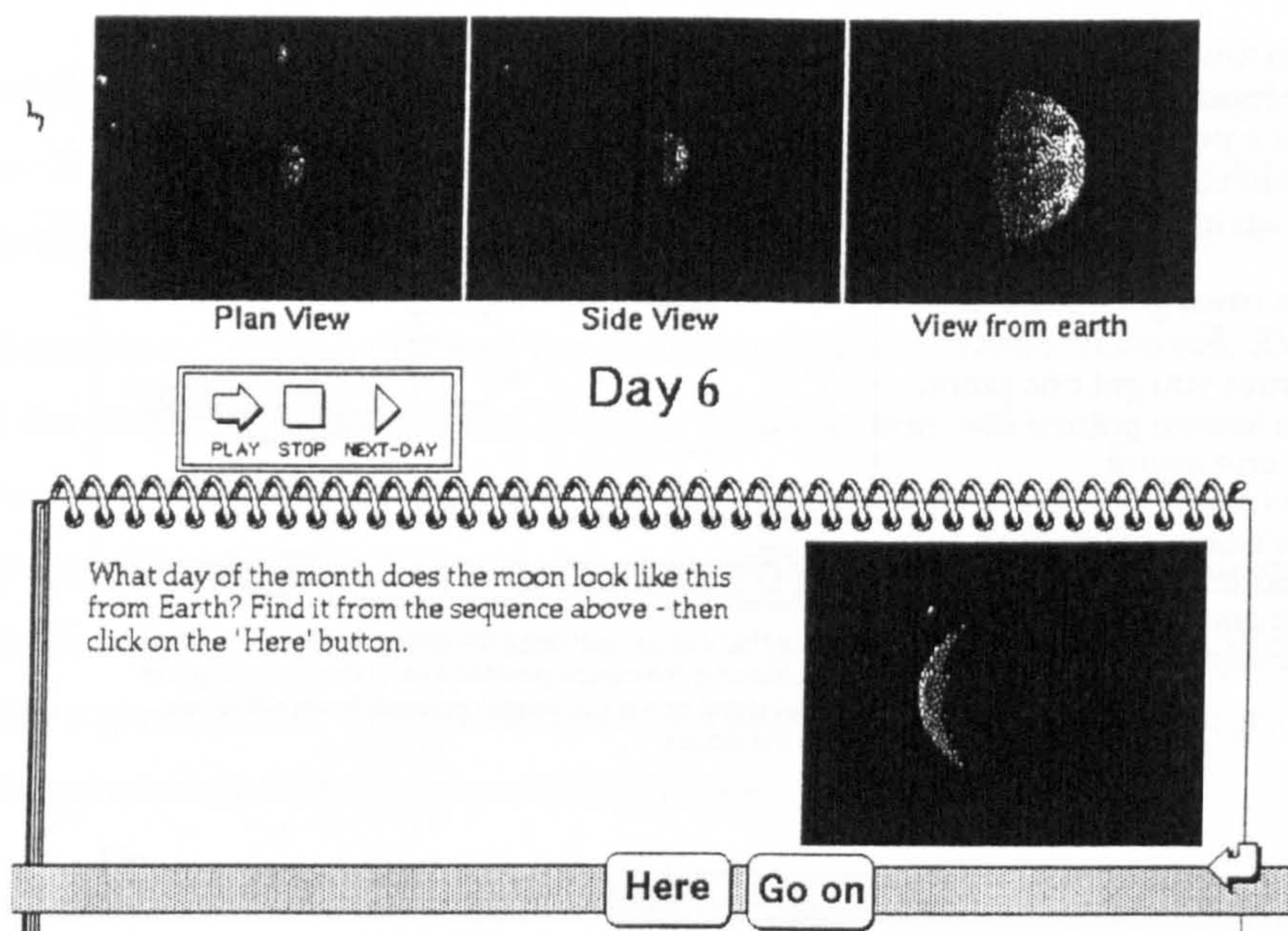


fig 5.9, Screen shot of Task 1

The students are asked to find at what point in the moon's orbit the view of the moon from earth matches the given view at the bottom of the screen. When students select the correct orbit position (day), they click the 'Here' button. The computer then encourages them to examine the position of the moon in relation to the sunlight and consider why the moon would look like it does from earth. If the students select the wrong position then the program describes the position that they have selected and asks them to consider how the correct position would be different and to try again. This feedback aims to describe why a particular selection was incorrect. In doing so learners are able to learn something more from incorrect responses than that they were wrong. It was hoped that by asking the learners to contrast their incorrect answer with the view of the moon that they were aiming for, they would see the relationship between the two. This may help learners with systematic errors such as confusing waxing and waning moons.

Responses to the students' answers are re-inforced audibly with an orchestral chord for correct and a duck's quack for incorrect. Students may answer as many questions in this task as they like and are free to return to the contents page or Task 2 at any point.

There are two ways in which a student may arrive at the task screen, either by selecting the task from the contents menu, or by switching to this task from Task 2. If the student has switched from Task 2 to Task 1, then Task 1 contains an extra button to allow them to switch back. Otherwise the only route from Task 1 is back to the contents page.

Task Two

Task Two takes the student a step further than Task 1. Task 1 was designed to help students understand why the moon appears as it does at different parts of its orbit. Task 2 tests this knowledge and requires the student to drag the icon of the moon on to the correct point in its orbit so that when viewed from earth it would look like the picture in the top right of the screen.

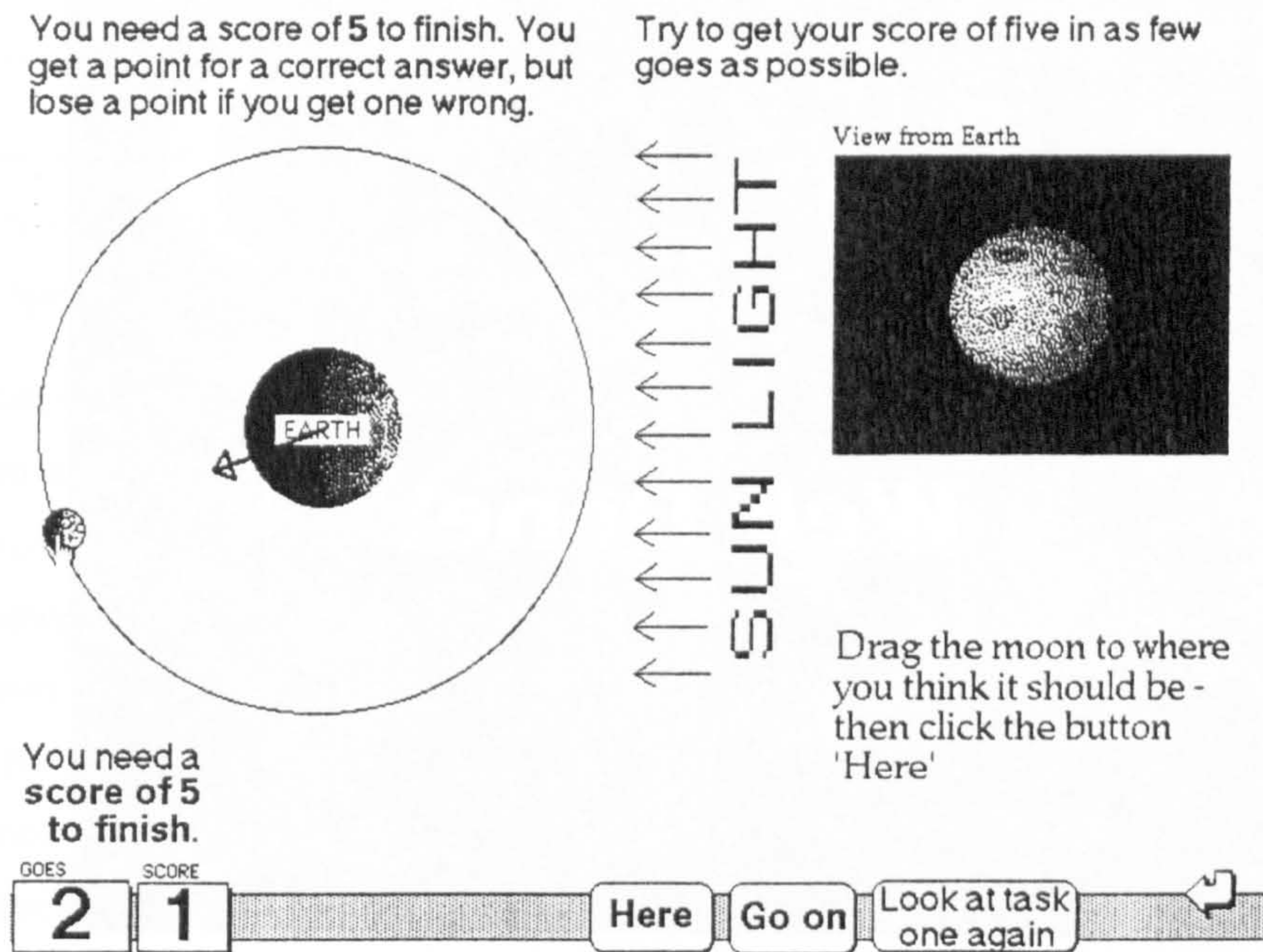


fig 5.10 Screen Shot of Task 2

When the students think that they have positioned the moon correctly on its orbit they click the 'Here' button. A smaller view at the bottom of the screen then shows what the moon would actually look like at that point in its orbit. If the student has positioned correctly then this small picture will match the larger one at the top right. As in Task 1, right or wrong answers are re-enforced audibly. A button at the bottom of the screen gives them access back to Task 1. Looking at Task 1 or returning to the 'About the Moon' section should help the student with any problems that Task 2 may show up. A score of one is added for each correct answer, or subtracted for a wrong answer. The students' aim is to get a score of five; when they do, the task is complete. The score is not allowed to become negative, so no score is subtracted for an incorrect answer if they already have a score of zero. The scoring mechanism was put in place so that students cannot complete the program until they have shown that they can correctly place the moon on its orbit for a given phase. Since placing the moon correctly requires that the user understands how the phases of the moon change, to achieve a score of five requires the students to have this level of understanding. The scoring mechanism also provides another goal for the interaction. The students' aims are to score five points, and to understand how the phases of the moon change.

Once the students have completed the task they are rewarded with an animated fireworks display and some spinning text saying 'Well Done' (figure 5.11), at which point the program comes to an end. If the program was implemented outside the environment of the study it would perhaps be more appropriate to return the learners to the contents page which would provide an option to quit. Returning the learners to the contents page in this manner would allow students to review sections should they desire to do so.



fig 5.11, Finalé Screen

5.2.2. Design Considerations

The design of the Phase 2 program was motivated both by the Phase 1 results and by the literature, the aim being to create a multimedia program that, in interface and courseware design, made use of multimedia attributes.

Interface design

As in the last phase, the program's interface followed guidelines from Brown (1988) and Chabay Sherwood (1992) where appropriate.

The findings of Phase 1 showed that users read on-screen text that was associated with a visual element. Phase 2 was designed with this in mind: large blocks of text were always associated with some related visual element.

Tackling misconceptions

A number of students in phase one were hindered by misconceptions about what made the moon look a different shape. They either thought that the earth cast a shadow on the moon,

or that something came between the earth and the moon that blocked the view of part of the moon making it look like a crescent. As the section 'Program Description' showed earlier, the section 'About the Moon' was designed to tackle these misconceptions. The section explains clearly how the sunlight shines on only half of the moon, and how someone on earth sees differing amounts of this half during a lunar month. The section also explains how the moon's orbit is inclined, stopping us seeing a lunar eclipse every month.

Feedback issues

Feedback on users' actions is central to interactivity. Without carefully thought out feedback the students will be unsure of their progress. Good feedback should allow the students to gain general or specific information about their actions.

The program employs both intrinsic and extrinsic feedback. Intrinsic feedback is feedback that is given as a natural consequence of users' actions. Intrinsic feedback in Task 1 takes the form of a visual display of the moon at their chosen point in its orbit. This can be compared with the viewpoint they are trying to match (given in the notebook, see fig 1). Comparison of the two views reveals the difference between the current position of the moon and the view of the moon that they are aiming to find. This enables students to adjust their answers based on the difference between the two views. Intrinsic feedback is also evident as the users click the control buttons to play, stop or advance the moon's position.

Extrinsic feedback is feedback that acts as a comment on an action, rather than being a direct consequence. In Task 1 extrinsic feedback is used when a student has selected the wrong point in the sequence. They are told that they have chosen incorrectly. A textual description tells them how sunlight on the moon at that point would make it look and they are also invited to re-examine the views and follow the path of the sunlight. (fig 5.12). Users who identify the correct point are told so and asked to note the position of the moon in its orbit.

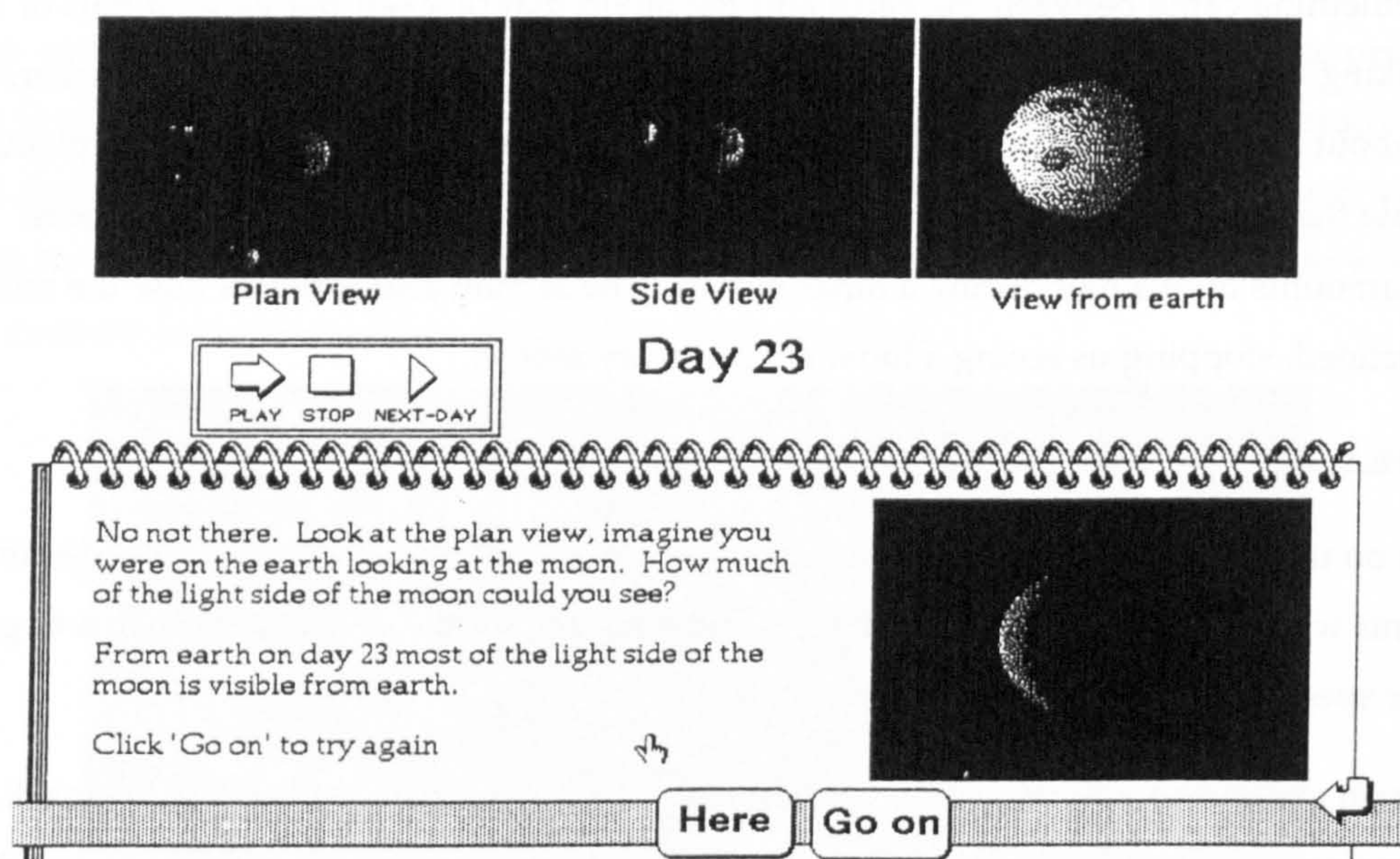


fig 5.12 Feedback in Task 1.

In Task 2, intrinsic feedback is used when a student positions the moon in its orbit, and is shown a view of what the moon would look like at that point from earth. They are shown this whether they positioned it correctly or not. A text box informs them if they have positioned the moon correctly, providing extrinsic feedback on their actions. The view they are given helps the students associate that view with that position on the orbit. They are also asked to consider why the moon appears as it does. At times the students may position the moon in the correct quadrant but not exactly enough to be awarded a mark. At these positions students are given a comment that lets them know how closely they have positioned the moon to the correct point. (fig 5.13)

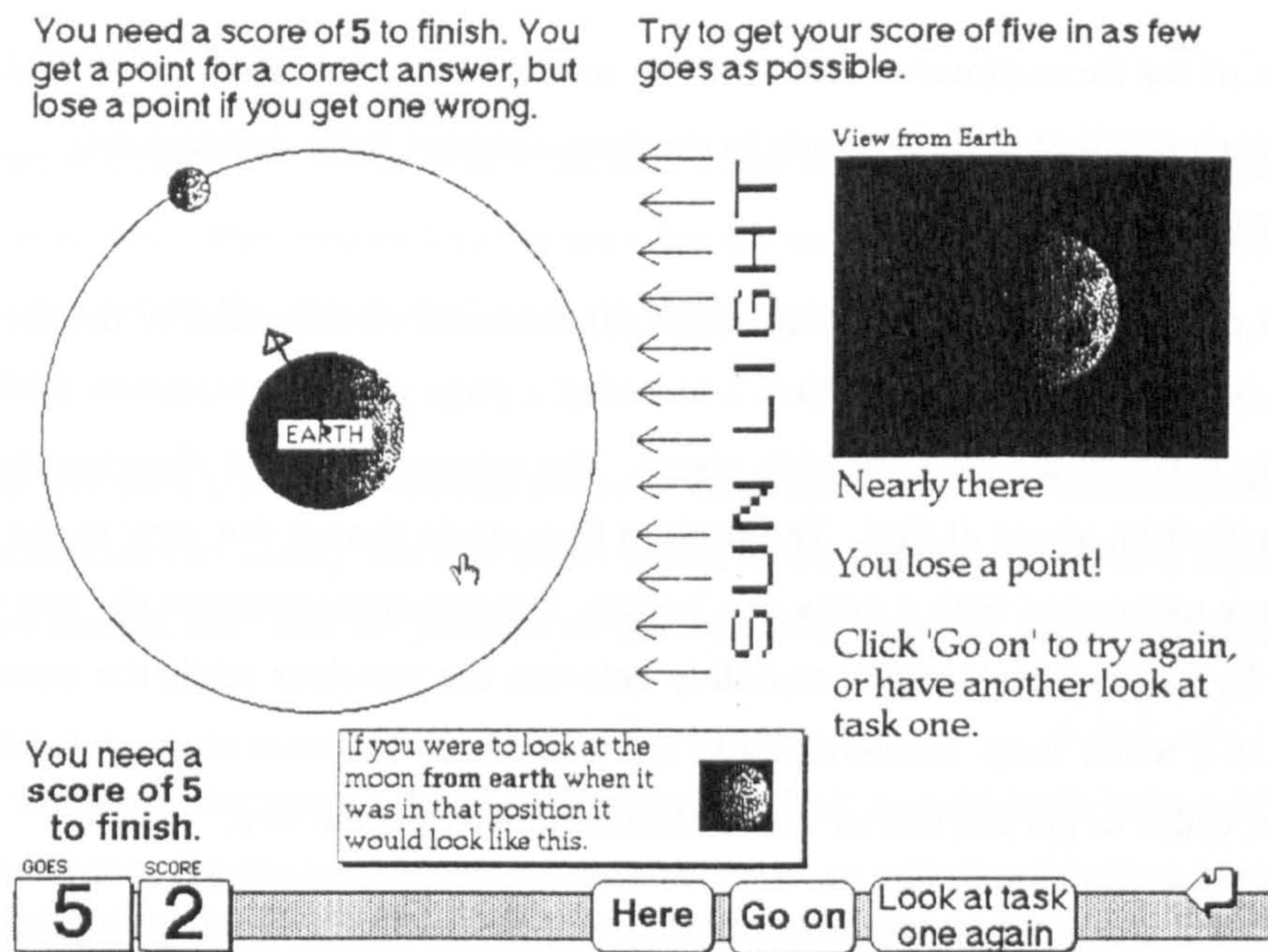


Fig 5.13 Task 2 feedback

In both tasks, sound accompanies correct / incorrect feedback responses. An orchestral chord is played if the student answers correctly otherwise a duck quack sound is played.

Design of scoring mechanism

It was hoped that the scoring mechanism which subtracts a point each time they make an incorrect response would force the students into thinking about how to get the questions right, and so require them to work out how the phase of the moon changes. It was also hoped that any initial difficulties in getting correct answers on Task 2 would encourage the learners to return to, and re examine, Task 1. In their re-examination of Task 1 attention would be directed by the type of problems they had had with Task 2.

Establishing relationships between views

The video of the moon's orbit around the earth that was used in the Phase 1 programs (in the last chapter) was of a model that had been built in the television studio. The three dimensionality of the model was easy to perceive since the viewers could identify with the scale of the model in the studio. The presenter walking around the model also helped to show the narrative space of the model. Being able to relate to the three dimensional space of the model in the studio may have contributed to the success of the film clip where the presenter lifts the moon up out of the earth's shadow.

The representation of three dimensional space in the interactive model of the tasks in this phase is not as clear. Instead of a narrative space constructed using video, students are presented with three views of the earth / moon computer generated model. This model provides users with much greater freedom in control, but the three fixed views do not promote

the perception of the three dimensionality of this model, unless the users are skilled at putting elevations together in their minds to produce a mental three dimensional understanding of the model.

Anticipating a possible problem then with three dimensional visualisation of the computer generated model, the instructions for Task 1 included a page with an animation that clarifies the relationship between the plan and side views. The animation looped showing the moon orbiting the earth from above at first. The student then could change the view to see the side view of the same movement with a press of a button. The transition between the two views was animated by moving the 'camera' smoothly between the positions while the moon's orbit was drawn in as a 'while' loop. Students could move between the views as many times as they wanted in order to get the feel of the relationship between the two.

It was hoped that this animation would supplant the mental process of converting between plan and side elevations. Students who had not visualised the connection between plan and side views should be able to do so after seeing the video that connects the two. For students who can already translate the two views into a three dimensional understanding, the video might reinforce this understanding for this program.

A further similar animation which showed the relationship between plan view or side view and the view of the moon from earth would have been ideal. The technicalities of producing such a clip were complex and consequently the clip was not produced.

Explanation of the lunar eclipse

The original video program and Phase 1 multimedia programs both dealt with the issue of "if the moon's orbit is inclined so that we don't get a lunar eclipse every month -- how and when do we have a lunar eclipse?".

To understand this fully is difficult, and requires the user to take into account the movement of the earth round the sun and the moon's orbit around the earth.

The original video programme did not deal with this in any depth, and none of the viewers could explain this after watching it. The programs in the first phase contained the explanation on the same level as the original video; again the subjects could not understand this. After looking at ways in which this phenomenon could be included in Phase 2, it was apparent that the movements were complex and not easily represented. Since the study is primarily about users' interaction with multimedia and not about learning the moon's movement this added complication was omitted in favour of focusing on phases of the moon as the key conceptual point to be made.

Include inclined orbits?

A consideration during the design was to include in the tasks an option to incline the moon's orbit. This may have demonstrated to the user that the moon's crescent could not be caused by the earth's shadow on the moon, and so may have helped to further dispel this misconception.

If the students moved the moon around a non-inclined orbit they would have found that there is no way that they can satisfy the full moon scenario, that there would have been a lunar eclipse every month, and that the shadow of the moon on the earth did not properly form a crescent.

The ability to change the moon's orbital inclination in Task 1 could have been added by allowing students to choose between an animation sequence with the moon's orbit inclined and one where it was not. This option was not even included. Though this extra option may have tackled some students' conceptual problems, it was clear that in general it would have added an extra dimension for confusion and misconceptions.

The disadvantage of using a non-inclined orbit is that it is a common but incorrect representation of the moon's orbit. It is not good to have students considering an incorrect representation of the moon's system, especially when the incorrect representation appears to explain most of the observed phenomena. The incorrect system also includes lunar and solar eclipses - though it does not show correctly how these occur. Since the eclipses are not dealt with fully in the tasks, students may assume that the moon sometimes orbits without an inclination in order for these phenomena to happen. Indeed students from the first phase did conclude that for a lunar eclipse to occur the inclination of the moon's orbit must change.

Q: What about a lunar eclipse?

Nills: That's where it's behind [the earth] and below [where it would be for a full moon]

Q: What happens once a year to make you see a lunar eclipse and not a full moon?

Nills: What I was meaning was because the earth is spinning on an axis across there and once a year the angle will come down to there and so the moon will be down there [behind the earth] usually it's up there.

It was important that program in Phase 2 included information about the inclined orbit, but instead of requiring students to consider scenarios with and without the inclined orbits an explanation about the orbit was included in the first program section 'About the Moon'.

Representation of point of view

After the first two pairs of students had worked with the program, it became clear that there was a conceptual problem with the way that Task 2 gave its feedback.

Students, during Task 2, are given a view of the moon from earth and are required to indicate on a plan view of the earth, at what point the moon would be in its orbit when the moon would look like the picture given. They indicate the position by dragging a moon icon to the place on the plan view of the earth and moon orbit.

If they get the position incorrect then the moon icon, which is still at the incorrect position on the orbit where the user left it, is changed into a little picture of the moon as it would be seen from earth if it was in that position. The problem is that the *plan* view now has a picture on it that is from a different viewpoint. A *plan* view of the moon at any point on its orbit will always look half dark and half light.

The conflict in viewpoints could seriously undermine the students' understanding of the system. The representation would encourage students to think in two dimensional terms as they are encouraged to think "at point X on the plan view the moon looks like Y". There is less motivation to consider the three dimensional system, which is essential in understanding the moon phases.

The problem was tackled by showing, in a separate box at the bottom of the screen, how the moon would look from earth if it was at point X in its orbit. Text accompanying the picture reminded users that this was a view from earth. Also relief shading was added to the icon of the moon and the plan view of the earth, giving them a three dimensional feel in order to help users keep the three dimensionality in mind. The shading has the added benefit of emphasising the position of the light source.

Technicalities of design

Scenes of the moon and earth and the moon's orbit were simulated using a solid modelling package. It was possible to create a computer simulated moon / earth and set the moon in orbit around the earth. A computer simulated light source was placed in the position of the sun. The computer then generated and animated the scene with all shadows correctly placed.

It was not possible to properly scale the moon and earth, or the distance between them. Such scales would have left the moon and earth objects too small. This does give a false impression about the sizes and distances involved, but should not affect the principles of the system.

The Macintosh could not render the animation in real time, so a quick time movie was made of the animation. Since a computer rendered animation is less detailed than a digitised film clip, QuickTime was able to handle window sizes much larger than the windows in Phase 1.

Consequently it was possible to choose the size of the QuickTime videos and not be restricted to a small image size.

5.2.3. Design of the Empirical Study

The new program is designed to teach how and when lunar phases take place. The material for the multimedia program is based, as in Phase 1, on the material from the linear video and printed text of S102. This time the study deals solely with the Moon phases, and not Foucault's pendulum or retrograde motion of the planets.

The program described above was written in Apple Macintosh Hypercard, and uses Apple QuickTime for the video and animation.

Eight pairs of students from The Lord Grey school, Bletchley worked with the program. Six of the pairs were from the academic year ten (14/15 years old) and two pairs from year eight (12/13 years old).

The pairs were mixed in gender and were taken from science classes that were studying the related topic of 'Space and the Planets'.

A pre-test was administered before the students began working with the program and a 5 minute post test and a short (5-10 minute) interview were taken when they had finished.

The students were left to work at their own pace through the program, with no help or interruption from the experimenter. The students were not given any specific time constraints, but would have known the time constraint of the lesson that they had been taken out of. All students finished without prompting, leaving enough time for the post test and interview. The experimenter took observation notes of students' actions and comments. The study, pre / post test and the interview were recorded on audio cassette.

The pre and post tests were completed in the pairs in which they had worked, partly due to time constraints, but also so that their discussion about the answers they selected might reveal their strategy. The tests required the students to try to explain why the moon changes phase, and to show on a plan view diagram of the moon's orbit where the moon would be for a number of given phases of the moon. The students in the pre and post test were shown a series of diagrams of the moon at different phases. They were asked to mark on a plan view of the moon's orbit at which point the moon would appear from earth to be in the given phase. Aside from this there were fairly informal oral tests, since this seemed to be the best way to coax the students into talking about what they thought, rather than just saying 'I don't know' and giving up. The interview asked more general questions about the program, followed up any problems they had, and gauged the students' attitudes towards the program.

The HyperCard program recorded in what order students visited different 'pages' and how long they spent on each. The program also recorded the activity in the tasks: how many questions were attempted, how many attempts were made at each question and how many the students got correct. A sample record output file is in the appendix E.

Data analysis

All printed pre and post test sheets were marked as to how many of the moon's phases the pair correctly positioned. Half marks were given for an answer if the student positioned a waxing moon in the position of the similar waning moon, and vice versa. In these instances the students had got the shape of the crescent correct, but the light had been on the wrong side of the moon. A sample worksheet used for this task is in appendix D.

The students' spoken answers to pre and post tests were recorded and transcribed, so that qualitative information regarding students' understanding could be found from the transcripts. Transcriptions were made of all interviews and key parts of the study for the same reason. The transcription can be matched against hand-written notes of the time and can be used to fill in detail of what is going on at any point. These too can be matched against the computer recorded records to get a full picture. The data was systematically examined to reveal commonalties in data between different pairs of students. Any common feature was examined to see if the data collected supported the finding or not.

Each student's score in Task 2 was plotted against the number of attempts they had made, thus revealing information about their strategy and progress.

Average times spent on different screens and tasks were calculated from the computer-generated report, as was information about the paths the students took through the program.

5.3. Findings

Findings are based on the analysis of pre and post test results, observation studies, computer collected data, and student interviews. Findings are not only related to the design issues based on the results of Phase 1, but are also of an empirical nature .

5.3.1. Motivation

As discussed in Chapter Four, a particular problem that some students had in Phase 1 was one of motivation. The Phase 2 program tries to aid learner motivation in several ways: greater interaction, specific goals and a scoring mechanism.

Greater interaction aids concentration

Phase 1 covered the same material as the linear video and was structured similarly, the main difference between the version being the level of user control. The students in Phase 1 only had control at the level of deciding their pace through the material, and in the structured version also their route through the material. While these programs engaged the students in some activity, it was only a matter of moving through the material. As discussed in Chapter 2 this browsing activity cannot be described as interactive. Any lack of understanding of the material did not hinder their path through the programs.

The interaction involved with Phase 1 was of a similar type to the interaction necessary for the linear video: students were allowed to be as passive as they liked, or to concentrate on the subject matter to accommodate their level of interest, or to understand only as much as confirmed their original misconceptions.

This phase of the study required that the students interacted to a greater extent with the program. The tasks required the students to be actively involved in thinking up answers. Increased interaction - having to solve a task - helped maintain the student's concentration.

The students' activity can be seen in this transcript taken while they were working with Task 2. The discussion relates to where they should position the moon icon for each question.

Martin: Just underneath it, yeah go on try underneath it, try that, well if you were there, you're standing on there and you looked at it you should be able to see about (bing) oh yes

Rebecca: What bit was the other one on?

Martin: That was the other side but it's to there (quack) it was close though look, go on, oh no you don't go on do you just pull it back a bit (quack), I think it's more that way

Rebecca: It's not cause that was half Moon

Martin: Yeah, and we had it sort of less so (quack)

Rebecca: I said it wasn't

Martin: Yeah but when we had it over there it said it was wrong (quack)

Rebecca: Nearly there

Martin: That's it (bing)

Rebecca: Yes! See

[next question]

Martin: Go on, that would be right down the bottom there

Rebecca: It wouldn't it would be about there (quack)

Martin: Put it down there, it's the wrong side(quack) it's the wrong side you can see,
down there

Rebecca: Go on, go on, go on (bing)

Compared with student reactions in Phase 1, more student interaction can be clearly seen from how much this pair talk and what they say. Task 1 of Phase 2 is similar in content to page 'moon3' of Phase 1. Both sections allow the students to step through the phases of the moon, looking at a view of the moon from earth and a view of the moon and earth from outside the moon's orbit. The only interaction expected in Phase 1 was that the student should step through the sequence and see what happens. This was easily accomplished with a few mouse clicks. The section did not encourage or require the students to examine the sequence. Phase 2 required students to follow the sequence through to find certain phases of the moon. Once they had selected a spot in the sequence, the feedback asked them to consider the moon's movement and follow the light from the sun.

Of the ten pairs of students that did the multimedia versions of Phase 1, eight pairs either did not say anything at all, or just indicated to their partner that they were ready to proceed to the next card. There was a marked change in Phase 2. All pairs of students conversed during the tasks. All talked about either where to stop the sequence or whether the selected spot in the sequence was correct while comparing the two images.

Further evidence that greater interaction increased student concentration can be drawn from the students' attitudes to Task 1 of the Phase 2 compared to page 'moon3' of Phase 1. In Phase 2, during Task 1, two pairs of students remarked how they were enjoying it.

Specific goals direct learners' effort

Some of the students from Phase 1 had a problem with motivation. Many did not read on screen text or put any effort into following or understanding the subject matter. Part of the problem with Phase 1 lay in the fact that students did not know where to direct their efforts since the expected learning objectives were not clear. This phase attempted to rectify this by defining clearer goals. The overall learning objectives were stated clearly in the introduction screen (fig 5.14), and the tasks restated the aims.

As we look at the moon from night to night we see that its shape in the sky changes. Some night's its a full moon - others it's a crescent.

This program will help you understand how this apparent change of shape happens.

There are two exercises in the program.

Your aim is to get a score of five in the second exercise. When you do this then you have finished.

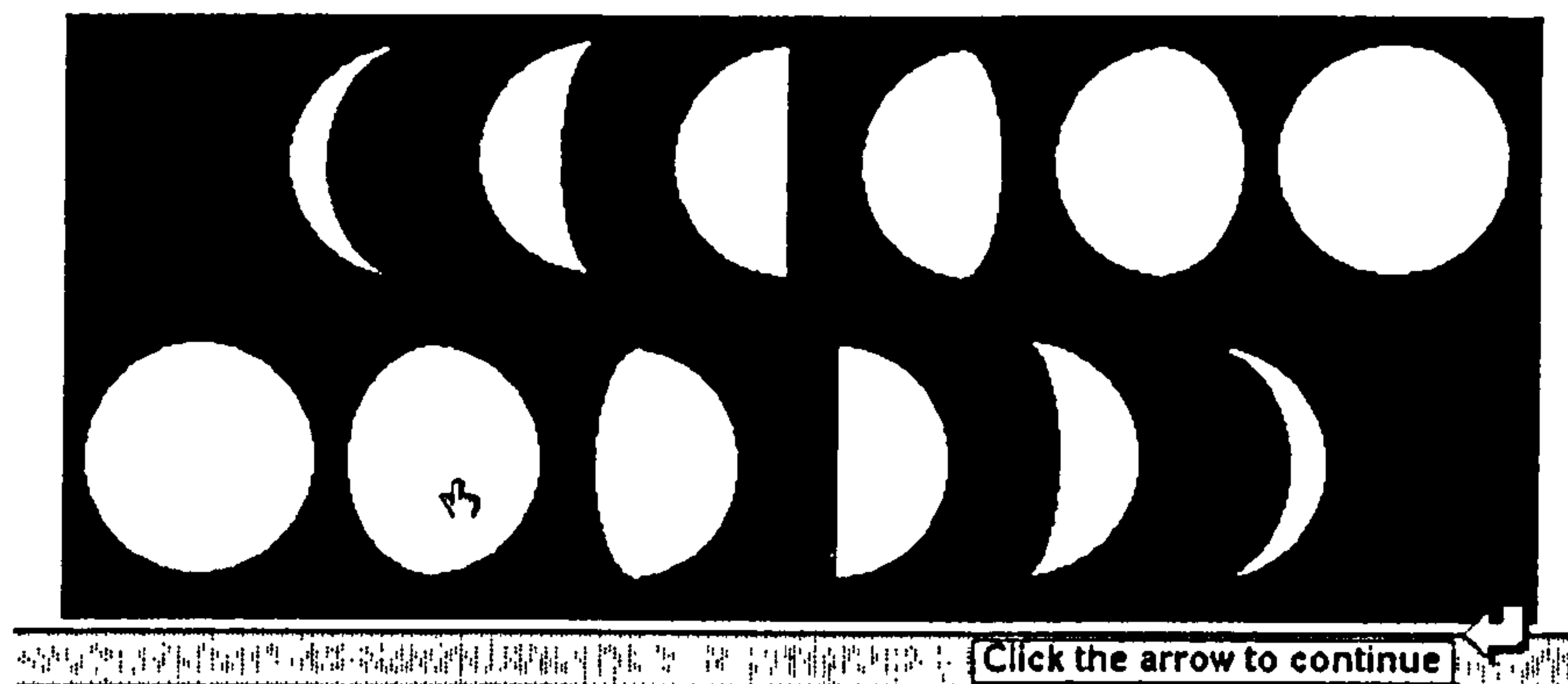


Fig 5.14 Aims of program clearly specified in introduction

The program succeeded in that the learners could show at which point in the moon's orbit a certain phase would occur. Understanding of how the moon's phases change was also better than the Phase 1 study.

Task Two set a secondary goal of gaining a score of five. Students' attention was drawn to this in the introduction by warning them that they would not be able to complete the program unless they had understood the phases of the moon sufficiently.

The scoring mechanism did work as a motivating device (see the next section), though it is not clear if learners paid extra attention to the sections preceeding Task 2 in anticipation of it. Students put a lot of effort into completing Task 2 (see the section on learner strategies), though their strategies meant that while they completed the task, they did so in ways that did not focus their attention on the subject matter but rather on the task.

The scoring mechanism that was meant to provide a secondary goal that focused the students' attention on the material had become a primary aim.

The effect of the scoring as a goal can be seen in the next section, but the effects of clearer educational goals are not easily discerned from the results, especially since they are swamped somewhat by the scoring mechanism.

The scoring mechanism increases students' motivation

The device which Task 2 employed, of forcing students to achieve a score of five points before they could complete the program, significantly motivated students by providing a short term goal to focus on.

Stephanie: Oh no we lost a point!

William: Was it there? Go back, look at Task 1. If we go back to look at Task 1 again then we'll see where they are, won't we cause we never looked at it properly

Stephanie: Full Moon is there, oh, go on

William: That's it! Here, that'll do (bing) We got three Steph

Stephanie: Er, down there, exactly in line, yeah? (bing)

William: We got four! We only need one more!

None of the students had any problem with the scoring mechanism, most found it motivating. Observation showed that when students had got a score of 3 or 4 they were particularly careful to get the next answer correct rather than risk losing a point. Graphs of score against attempts all show a steady increase at the end. None of the pairs that got 3 marks ever dropped back below two marks - even if previously they had got quite a number incorrect. fig 5.15 is a typical plot of the students' progress on Task 2.

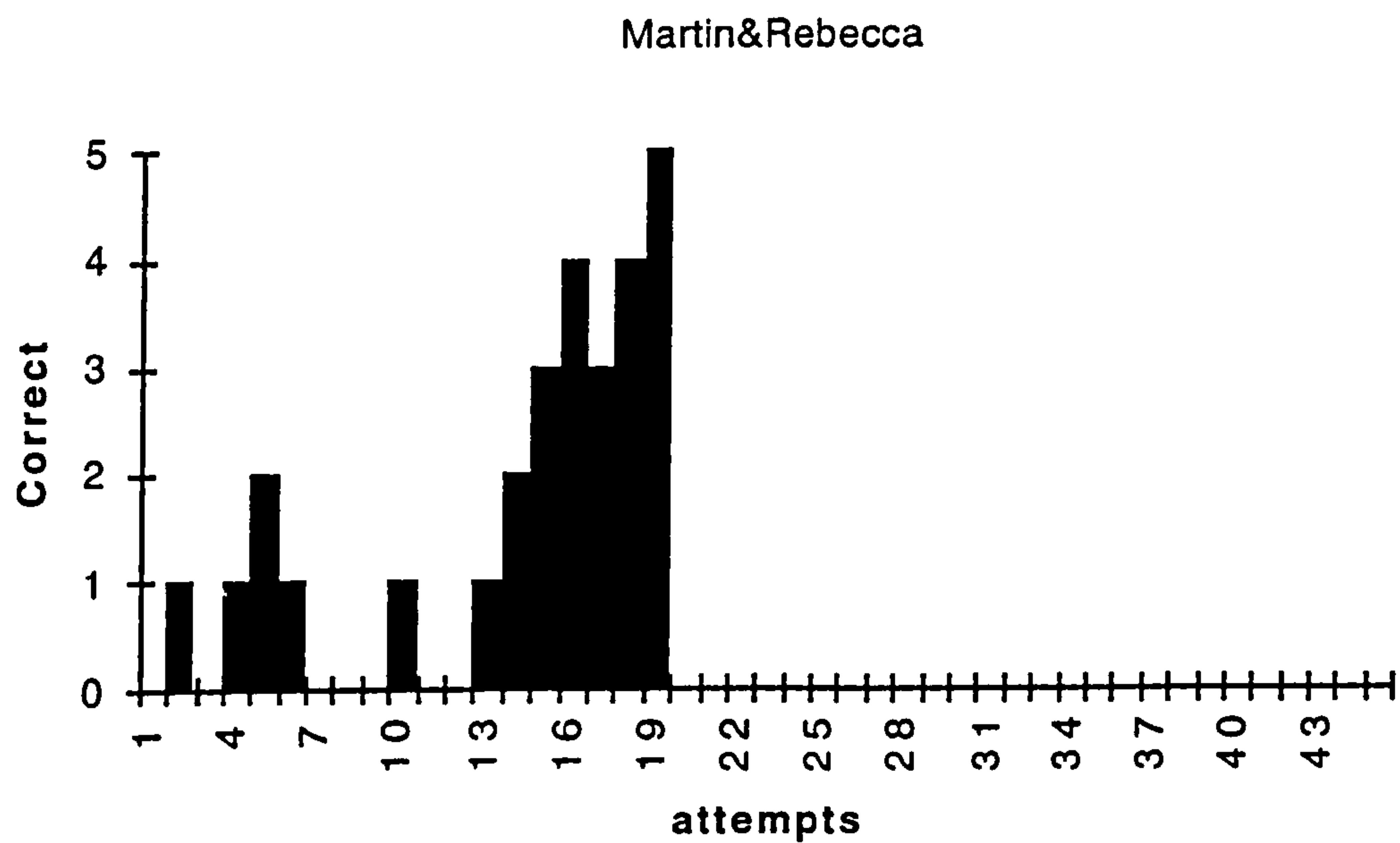


Fig 5.15 Example plot of score / attempts

There was a wide range in the number of attempts students took to gain the necessary five points they needed to continue. One particularly careful pair of year 8 students completed the task in just five attempts (each attempt correct). The pair that took the highest number of attempts, thirty six in total, did equally well in the post test. After this many attempted answers before getting enough score to finish, the pair showed no signs of frustration -- in fact when asked what they considered to be the best part of the program they replied :

Q: What was the one thing you liked best about the program? I mean, is there something you thought "that was good" or "that was useful", it really made you learn something, or something like that

Nisha: The last game

Steven: Yeah, placing the Moon

Also note that Nisha refers to the task as a 'game'. Neither the experimenter nor the program refers to the task in this way, but this is obviously how Nisha perceived the work in Task 2. Perhaps this perception of the task enabled Steven and Nisha to work with the task for the time they did without losing patience.

Andy also found the tasks enjoyable:

Andy: In actual fact I wouldn't have minded if there was more tasks to do, you could of got into it then and think, oh it's strange.

Q: You enjoyed it did you?

Andy: Yeah

Q: Right so you would have liked more tasks to do?

Andy: Yeah

His complaint was that there were not enough tasks.

The success of the scoring mechanism at encouraging the learners to think more deeply about how the phases change is discussed later in the section on learning strategies.

5.3.2. Learner Control

Navigation

Phase 2 offered a more open structure than either of the programs in Phase 1. Students could choose to examine any part of the program from the main menu. The menu was organised as a list and this therefore implied a sequence to follow. The implied sequence was also the logical sequence for the material. Students on the whole followed this sequence with only slight variation. What this structure offers is the ability to easily locate and review sections later.

Two of the students demonstrated that it was possible for them to deviate from the logical sequence of the program when they needed to. They had had some problems understanding how to operate Task 1 so they did not see the animated moon sequence, consequently they were finding Task 2 harder to complete. Instead of looking to Task 1 for help they remembered

that the 'about the moon' section had a description of how the moon orbited the earth and so returned to this .

During the interview, questions were asked to determine some measure of how well the students remembered the program's structure, and to see how easily they could find and return to a given point. Students were asked to name the different sections and the whereabouts of a particular piece of information in the program's structure. All the students asked could remember at least five of the six main menu options and most correctly identified the section which contained a certain video clip.

Q: Can you remember how the whole program was laid out. Like can you remember whereabouts at one point there was a video in a video and a man lifting a Moon up

Andrew: Yeah, that was good

Carly: That was after the 'about the Moon ' [section]

Q: That's right, and there was another bit where you saw a plan view and it changed to a side view, can you remember whereabouts that was?

Andrew: It was in something instructions...

Q: ...Can you remember how many options there were in the contents page?

Andrew: There was the introduction, Task 1 instructions Task 1

Carly: About the Moon

Andrew: Yeah about the Moon and there was Task 2 instructions and Task 2

Even though Andrew and Carly did not deviate from the logical sequential route, their answers showed that they still had a fairly clear memory of the program structure and where certain elements could be found. Perhaps if they felt they had needed to return to re-examine any sections they would have been able to do so.

Student control of pacing

There was no goal for the number of correct answers that had to be obtained in Task 1. Each time the students correctly positioned the sequence so that the position of the moon matched the given view of the moon from earth, they were given a new view to try. Learners were not told "right you have done enough of these, why don't you move on", but were left to decide themselves the appropriate point at which to continue with the rest of the program. It would have been possible for users to have stayed in this section for a long time, thinking that since they had not been told otherwise, they should continue in this section. Learners did not fall into this trap though. All the pairs decided that they had seen as much of the section as they wanted to and moved on without prompting. Students spent an average of five

and a half minutes in total on Task 1 (standard deviation of 1.5 minutes). The time spent on the task relates to the number of questions answered (or attempted answers). Students answered an average of 1.3 questions per minute.

It is important that users take the initiative in controlling their route through the program. As discussed in the Chapter Two section on 'The Role of Control in Learning', if learners have the confidence, knowledge and ability to control an educational program as they need to, then they can define a learning strategy of their own that best suits them. It is important then to look at what motivated the students to move onto the next section. In order to assess this it is necessary to examine the type of interaction in Task 1. The basis of Task 1 is simple. The users are given three video windows that show different views of the moon in its orbit around the earth. They are also given a view of the moon from earth. What they must do is move through the video in the windows (all three windows play simultaneously) to find at what point in the moon's orbit the moon matches the view given.

This task is simply a matter of matching the given picture to the moon view in the sequence. It is not meant to be difficult, but it makes the students examine the moon's orbit. When they answer a question correctly they are directed to think how the light on the moon would make it look as it does in its orbit, and when they get a question wrong they are asked to examine why it is wrong. In this way the task is not about getting it right or wrong, but about interactively examining the moon's orbit. Had they just been given the sequence to look through then perhaps the students would be less involved and so less sure what they should be looking for.

When the students understand how the moon system works there is no more motivation to stay on this section. Also there is only a finite number of types of view of the moon from earth. If the students remained in the task then the questions would become repetitive.

William: We are good at this aren't we? Oh that's easy <bing> That's it?

Stephanie: Yeah start this now [indicates the return to contents button]

William: I like this go on, enjoying this, could do loads couldn't we? That's it <bing>. Go on, oh one last one then, we done this one haven't we?

Stephanie: Yeah

William: They aint got no more for us, they're getting bored of us Steph.

Stephanie: You.

William: That's it <bing> Go on then, Task 2....

Stephanie and William showed they were quite sure about their options of when to move on. The section came to a natural end, still allowing students to determine when they moved on.

5.3.3. Learner Strategies

Observation and interviews revealed that learners used different strategies in both tasks in order to complete them. Identification of the learner strategies is important in understanding the user's approach and expectations in multimedia.

Different strategies in Task 1

It was anticipated that the learners would not appreciate the full significance of Task 1 when they first worked with it. Their first time through was expected to familiarise them with the moon / earth system and let them begin to appreciate what was involved. It was expected that students would realise the benefit of returning to Task 1 once they were challenged with a specific problem solving task relating to the system. Task 2 should have provided the problem that returning to Task 1 would help resolve. Instead though since the learners had found an alternative way of solving Task 2 that required less mental effort they did not return as often as expected. The interviews reveal that students were aware of the possible benefits of returning to Task 1, but instead they would rather solve the problem as a memory exercise.

Q: Do you think the first task helped you with the second task?

Vicki: It depends whether you looked at the other views or not

Vicki had realised that there was more to Task 1 than just matching the views. As directed, she had spent more time examining how the system worked in Task 1.

Vicki: But we didn't have to really look at the other views to get it right

Andy: I just matched up the plan and picture, you could get it so easy

Vicki showed that she had realised that you can complete the task without examining the different views. Andy had also seen this. The learners had been given the opportunity to decide for themselves in what detail they were going to do this task, though the program does prompt users to think through and examine each answer they make. There are two different strategies then for completing Task 1. The first strategy of matching the given view with the views on different days is easy and will enable the students to complete the task. The second strategy involves considering what is meant to be learnt from the task. The computer prompts the learners with what they should be looking for as they match the views.

Q: Do you think if you looked at the first task again when you were having trouble with the second task would that have helped, or wouldn't it be any help?

Andy: On the first one it shows you more like the days like the position of it, not the position sorry, what it would look like from that day, but it doesn't show you what position it would be at at that day, like round the orbit

Vicki: Yeah it does doesn't it? At the top bit

Andy: I don't remember it at all

Q: There's three windows at the top, what do they show?

Vicki: One of them showed the top view, one of them showed the plan view one of them showed what we could see

Andy demonstrates that he had just been concerned with the task of matching, to the extent that he had not considered the other on screen information important.

The pre-test shows that both Andy and Vicki started with the 'earth blocks the sunlight to the moon' misconception. In the interview Andy still maintained this misconception - despite doing well towards the end of Task 2 and completing the post test adequately. Vicki understood both why the moon changes phase and what positions the moon is in in its orbit for each phase. Andy worked on the level of what was necessary to satisfy the minimum requirements of the program. He was able to answer the questions adequately, but did so by using strategies that did not require him to go to the effort of trying to understand the concepts that the program was teaching. Instead, for Task 1 he matched the pictures, and for Task 2 he remembered the sequence of the phases rather than how they occur (discussed more in the next section).

The controls to Task 1 allowed two different methods for moving through the sequence of days. There was a play button that once pressed would cycle the animation repeatedly through and loop. The learner then can watch the moon doing accelerated orbits and watch how the phases change.

There were two possible methods of locating the correct point in the animation sequence. The first was to use the play button and then hit the stop button in order to halt the moon at the particular phase that they were trying to find.

The second method of moving through the sequence is to hit the 'next day' button. This button advances the moon along its orbit by one day. It is possible to step through the whole lunar month in this way to find the required day of the sequence. Students tended to use either one of the methods, once they had found one method that worked they would continue with this method and not try the other. The most efficient method would be to stop the video playing before the required day, and then step through to the exact position. Trying to stop the video on the exact position is hit and miss, especially given the comparatively sluggish response of HyperCard and QuickTime.

A further difference in the way users approached Task 1 was the way in which they prepared their answers. Some of the pairs would take care and time to match the views, working through the sequence a number of times before finally being satisfied with an answer and entering it.

Only one pair of students had some difficulty with Task 1. The first view of the moon that they had to find in this task was the one where the moon is near the sun in the sky and is not visible. Other pairs had not had any problem with this scenario when it was presented later in a test, but as a first question, this pair of students found it confusing and were unsure what to do. Consequently even though they played the sequence a couple of times they did not answer any of the questions for Task 1.

These students did return to Task 1 on three occasions while working with Task 2, but on none of the occasions did they attempt to answer the question or play the sequence again.

Task One worked well in that students worked with it in different ways, moving on without prompting. Students did answer the questions, and some referred back to this section later. It was hoped that poorly motivated students who just matched the pictures would be required to use this task in more depth once they got stuck on Task 2. Unfortunately since learners found other strategies to complete Task 2, reference to this task was not as common as it might have been.

Strategies in Task 2

All pairs of students had the same aim for Task 2. The aim was to get a score of five. The students were given a view of the moon from earth and had to mark on a plan view of the moon's orbit where it would be for that phase to be visible from earth. For every correct answer they were awarded one point; an incorrect answer meant a point was deducted. If they had a score of zero then the program did not deduct further points for incorrect answers. The students were allowed as many attempts as they required.

Observation, interviews and automatically recorded data reveal different learning strategies in Task 2.

The desired strategy for Task 2 would be something along the lines of:

- ❖ Try to predict the position of the moon by following the path of light from the sun and visualising a view from earth. .
- ❖ Make an attempt at positioning the moon - if it's wrong, examine the picture that shows what the moon really would look like if it was placed in your 'incorrect position'.

- ❖ Follow the light from the sun and visualise the view from earth for this position again then make another prediction for the position based on any new considerations.
- ❖ If your prediction is correct, follow your reasoning through again to see why.
- ❖ To help visualisation of the system, returning to Task 1 would be valuable as this shows the moon's orbit from different views and allows the user to step through the different positions.

Students were not given this specific advice. Only a few followed a strategy of this type. In fact students had a number of different strategies for completing Task 2. The stated goal was to understand the phases of the moon. The students' primary goal was to achieve a score of five in order that they could complete the program.

The common method of tackling the task was to adopt a 'try and see' approach at first. This approach did not enable students to increase their scores: many of their answers were incorrect at first since by simply guessing positions it was unlikely that a total of five points could ever be reached. During this time they were remembering the positions for certain phases they got correct. They also used the feedback for positions that were incorrect to remember the position of the phases. Further to this, they attempted to construct a model of how the phases change around the moon's orbit.

Andy revealed that part of his strategy for completing Task 2 was memorisation- recalling which views are associated with which positions

Q: Right, at first you got a lot wrong didn't you?

Andy: On the second task it was quite hard at the beginning, but then once you got the pictures of like when you got wrong it changed you can remember them.

When William was asked in the post test to place the moon on its orbit for a certain phase he vocalised his reasoning. He described how the moon changes shape as it travels round its orbit: starting at one end with a new moon - working through phases to a full moon, then back through the phases.

William: Cause it comes up round to a full Moon then doesn't go straight to the new Moon it goes back to the half Moon, then back to the new Moon. So it comes back in phases, so it comes round there like that and it comes back in phases and goes down there and it goes to the new, should be here.

Andy also described his method of working out where to place the moons on the diagram.

Andy: No, you knew the full Moon was there and the one you couldn't see was there, but we didn't know where the others were, really until we'd figured it out that it went big from there onto that side sort of thing and it went round

With this method that he worked out he was able to complete Task 2, as well as the post test. It is possible for a learner to work out this sequence from the program, but this system, while effective in answering the question and in getting across the idea of how the moon changes, does not involve students reasoning why the moon appears as a crescent.

Graphs of scores plotted against number of attempts indicate the students' strategy. Most pairs of students started by getting most answers wrong, which did not concern them particularly. Once they started getting questions correct and worked out their system of answering, they quickly completed the task.

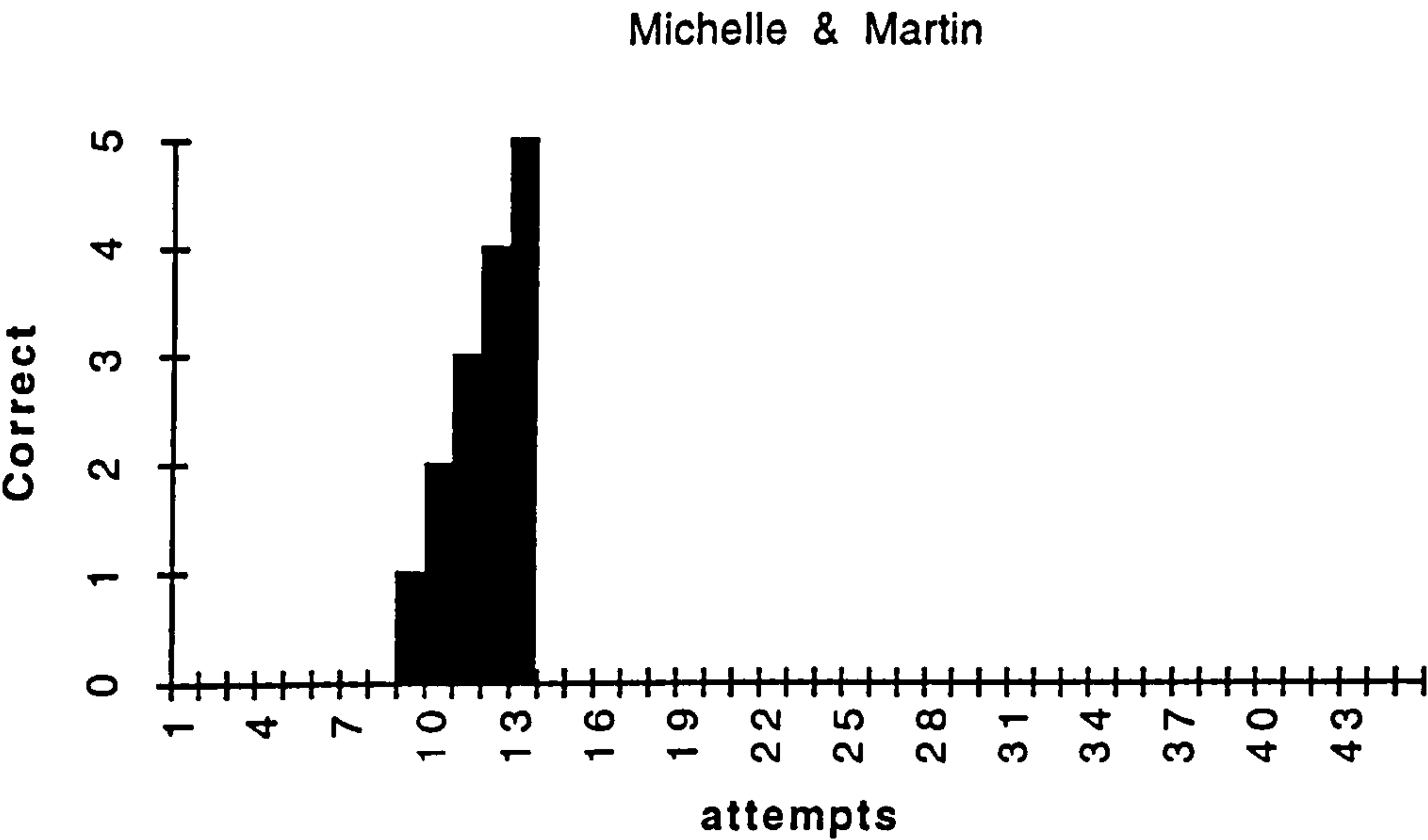


fig 5.16 Number attempts plotted against score

No students found themselves getting three or four questions correct and then falling back down to zero. This indicates two possibilities: (a) that they tried much harder not to get any wrong once they had a few right, and (b) that they successfully worked out how to answer the questions. The evidence suggests that both scenarios play a part.

Figure 5.16 shows that Michelle and Martin made 9 attempts at positioning the moon, and then were able to get five correct answers in a row.

To work out where to position the moon the students examined the feedback and used that to adjust their next attempt. 'It gets darker if we move it that way - and lighter this way - we'll try it in the middle.'

It is possible to see students trying to find rules to explain where the correct position of the moon is:

William: Round there, or was it that side [of the orbit], no it's this side innit, down there, yeah, it's this side, yeah here (bing) Oh good, this side up here, exactly the same as that one but different [meaning the other side of the orbit], innit, so it should be up there, innit? That's a crescent up there, innit?

Stephanie: Oh yeah

William: No it's not, it's a crescent down there, cause it comes round, it fades this way, it's there (quack) Nearly there, oh, we have to be exact do we?

Stephanie: Oh hang on, what's that one? That's a bit less, so we have to go [indicates a bit further round the orbit]..

William: Down that way

Stephanie: This way?

William: Mm, that'll do (quack) No, not there

Stephanie: Oh, that goes darker this way, go to the other side

William: It can't be on the other side can it cause that would be turned that way [upside down] instead of that way, wouldn't it?

Stephanie: Yeah, I know, but that was a thin one wasn't it? (quack) No not there, oh that was a full Moon, it should be up the top (bing)

The above transcript of Stephanie and William working on Task 2 demonstrates their rule finding strategy for locating the position of a particular crescent. They are considering which side of the moon the light falls on ('which way up it is'), and whether it gets more or less light as it moves round its orbit. Once, through experimentation, they determined the answers to these they were able to position the moon correctly on the orbit.

The feedback that the program provided after each attempt, correct or not, by showing at the bottom of the screen a small representation of what the moon would look like from earth at the chosen position was important. Without this all that a student learns from placing the moon incorrectly is that the moon is not in that position for that phase. The student can think through the reasoning for this and so help construct a mental model of the system, but this must be facilitated if they are given the feedback of how the moon looks at that point. They can then work from 'the moon doesn't look how I predicted it would, but does look like the picture that the feedback shows' when they make an incorrect attempt. Even without this deep level thinking a student working at a surface level does receive new information with each attempt which they can use to formulate their next attempt. Steven and Nisha give this capability as the reason why they thought Task 2 was good.

Q: Why was that [task 2] good?

S: Cause, like, you had to do it yourself, you just learned each time you got something wrong

N: Yeah, then you just look up from the

S: From the little picture chart, like, and have to put it right yourself

One pair of students, Dee and Lewis, did make significant use of Task 1 in order to help them in Task 2. They had been unable to work Task 1 since they had not discovered how to answer the questions. Because of this they had not benefited from working with Task 1. This made working with Task 2 more difficult than it otherwise should have been. Dee and Lewis had realised that they had missed out on some aspect of Task 1, but still referred to it three times during working with Task 2. When they returned to Task 1 they still did not step through the animation but did seem to appreciate the three static views of the earth and moon from space that it offered. There was no discussion between the pair about why they should return to Task 1 other than stating it as an idea.

From working with Task 2 using the 'try and see' approach as discussed above they had realised that there was a sequence to the phases of the moon.

Dee: as it moves that way it gets darker, other way lighter.

After returning to Task 1 twice, their efforts to determine the sequence led them to remember that during one of the previous sections there had been a page which showed the phases of the moon in order. After asking the experimenter where the chart was and getting no help they returned to the contents page and then to the 'Introduction' page which does show the phases in sequence.

More experimenting on Task 2 and a further look at Task 1 did enable them to establish the sequence and complete the task. Despite the problems they had with the program they appeared to enjoy the experience still and asked if they could return that afternoon and work some more with the program.

The scoring system was designed to help students understand phases of the moon by motivating them to concentrate on the content and build the right interrelations. The scoring system naturally defined their new goal. This new goal would have been acceptable had the learners still had to understand the phases of the moon in order to reach it, but unfortunately students found a conceptually easier method of achieving their goal - memorisation of the sequence of phases rather than comprehension of how the phases occur.

The task was successful in engaging the students in a learning activity, the scoring being successful in motivation. Even students that were not motivated well in Task 1 were engaged in Task 2. The level of concentration was good for these students too, who did not even become frustrated by having a large number of attempts to get a score of five. Unfortunately most of the learners did not address the learning at a deep enough level using memorisation rather than understanding to complete the task. Task design and scoring played roles in this.

5.3.4. Learning Gain

Direct comparison of pre and post test results gives a quantitative measure of the students' learning gain. Students were given six different phases of the moon. They had to mark the position of each phase on a plan view of the moon's orbit which had the direction of the sun marked.. Details of the marking are discussed in the methodology section.

In the pre-test, students scored an average of 14% (see the 'Design of the Empirical Study Methodology' section for how this was done). Average post test results showed a gain of 61% (sd 26%) giving a total of 75%. Since Phase 1 covered greater ground than the second phase, direct quantitative comparisons between the learning gains are difficult. The figures do show a substantial difference in the learning gain. The mean gain for the first phase was just 5.6%.

As discussed in the previous chapter, the difference in learning gain between the three elements of Phase 1 (the structured and linear versions, and the original video tape) was negligible -- the main difference being the type of learning strategies.

Students in the pre-test in Phase 2 had exactly the same misconceptions as students in phase one's pre-tests. These were that the moon's crescent was produced by:

- (a) some object coming between the earth and moon or
- (b) that the earth casts a shadow on the moon or
- (c) that part of the earth itself blocks the view.

Nine of the ten pairs of students in Phase 1 had these misconceptions before they started the multimedia programs. Four pairs of students still maintained their misconceptions in the post-test. In Phase 2, only one of four pairs who had misconceptions about why the moon appears to be a crescent kept their misconception.

5.4. Conclusions

5.4.1. Interaction

There was far greater enthusiasm for the Phase 2 program. The increased interaction needed to work with the program led to greater engagement with the program and more enthusiasm. This increase in activity also led to more interpair communication as the students decided on their actions. This discussion was not just about control aspects of the program but was largely about the content. However most of it was surface level approaches rather than deeper analysis which, as discussed, can perhaps be attributed to program design in this instance.

The students who worked with the program were positive in their attitudes to learning in this way, though studies before have found that the 'novelty' value of these systems plays some part in the positive perception.

The students worked well with Task 2, not getting weighed down even by quite a large number of incorrect attempts, unlike the frustration felt by users of Terminal RISK in chapter three, as they repeatedly got incorrect solutions during the flowcharting task. The scoring mechanism, the intrinsic and extrinsic feedback and the student knowledge of their own progress that this task offers must play a part in this.

5.4.2. Learner Goals

The surface level approach in Task 2 that allowed students to complete the program by using surface level strategies rather than deeper processing is partly due to insufficiently defined learning objectives. The learning objectives for the program need to define how the program would know that the learning goal had been met. The original assumption that being able to place the moon correctly in its orbit for a given phase does not stand up to scrutiny as a test of whether the learner understands why the phases of the moon change. Laurillard (1993) describes a procedure for defining learning objectives that could be used to define learning objectives:

1. State the aim X
2. Define a behaviour, Y, that would demonstrate to you that a student had achieved this aim.
3. Is Y defined precisely enough that you could agree with a colleague about whether a student was exhibiting that behaviour? If not return to 2, and refine the definition.

4. Is the aim achievable without being able to do Y? If so, and if Y is a useful behaviour, then devise an additional aim that fits Y. Otherwise return to 2 and refine and replace the definition.
5. Does the collection of 'Y's generated so far cover everything implicit in X? If not, then return to 2 and generate an additional Y.
6. List the aim and objectives so defined.

(Laurillard, 1993; 221)

Using this procedure for the learning objectives of the program in this phase the result would be as follows:

1. Aim: to understand why the moon changes phase.
 2. To be able to position the moon on its orbit so that a specified phase would be seen from earth.
 3. Yes
 4. Yes, remembering the sequence of phases the moon goes through during its orbit can achieve the behaviour in 2. Placing the moon on the orbit is a useful behaviour so include a new definition at step 2, to read "describe how light falling on the moon is seen from earth at different times of the month" and then repeat steps 2 and three.
 5. Yes
 6. Aim: To understand why the moon changes phase.
- Objectives: To be able to position the moon on its orbit so that a specified phase would be seen from earth.
- Describe how light falling on the moon is seen from earth at different times of the month.

A free answer to the new objective would be difficult to include in a multimedia environment. This kind of description was asked for as part of the post-test and students found it hard to describe without using a drawing. Some time and imagination would probably provide some way of making this kind of description in a computerised environment.

The importance of careful pedagogical design is highlighted by this example. This type of procedure would need to be undertaken by the subject expert during design of the multimedia.

5.4.3. Misconceptions - the Importance of Program Testing

The first phase revealed common misconceptions and problems with understanding the phases of the moon. Phase 2 took these into account in the design by specifically addressing them. Few students, as a result, finished the program with these misconceptions. This helps to validate the new design features introduced and also illustrates one of the benefits of piloting the program with its intended audience.

The second program was only tested during its design using subjects from the university. These people approached learning from the program as expected. They tried to answer the questions in Task 2 by visualising the moon, the earth and the direction of the sunlight and in doing so had to understand the principles involved. This approach was the one I had anticipated and so served to confirm my expectations that the students at the school would approach the material in a similar manner. The actual approach of students was, as discussed above, that of working out the sequence of the moon's phases and associating certain positions of the moon with a certain phase. Field testing the program with the intended audience would have brought this approach to light before the study commenced and would have allowed time for a version which discouraged this approach to be designed.

5.4.4. Motivational Devices

The idea of using scoring was successful. The task could have allowed students to attempt as many questions as they wanted. Less well intentioned and motivated students may have found working like that difficult. Task 1 was open-ended and did not employ devices other than simple textual suggestion to encourage the students to examine the material -- why then did students not have problems with it? Task 1 was an easy task. As long as the students had enough motivation to work out what to do then the positive rewards of correct answers were easy to attain. Most students worked with the task until they were confident that they knew how to answer the questions and then moved on. Even though students were encouraged to examine the task in greater detail many did not. It was hoped though that students who had passed over Task 1 as easy would find themselves driven back into it by the complexity of Task 2.

Students did not find the scoring annoying, and even pairs that spent some time collecting enough points to continue did not show signs of frustration. There is potential for similar devices to be very frustrating if not properly implemented. The goal that they must satisfy before they continue must be achievable. If it is a complex goal then there must be help and guidance for students who have problems attaining it. In this phase it was hoped that Task 2 would be tricky and drive students back into Task 1 and other information in order that they

could complete the task. Task 2 was not as difficult for the students as anticipated, as discussed in the strategies section.

5.4.5. Evidence that the Learner Can Take Control of Learning When Left in Charge

Task 1 relied on students moving on from the task when they were ready. There was no prompting.

Learners demonstrated that they were able and confident enough to take control of the task and move on when ready.

5.4.6. Different Goal-Oriented Strategies (Good / Bad / Routes to the Same Goal)

A principal problem with Phase 2 was that students managed to short-circuit the main cognitive aspect of the program. Students were able to pass the post-test without having to complete the complex mental visualisations and transformations involved in working out what the moon looks like from earth by following light from the sun, and keeping in mind an exterior view of the earth / moon / sun system.

Students could predict, given a plan view of the moon's orbit, what the moon would look like from earth at any point. It is likely that this understanding is shallow since it is not based on an actual understanding of how the system works. Perhaps if these students are presented with a different representation of the system they would not be able to make predictions, whereas if they understood how the system worked they should be able to work it out. After this study their knowledge is based on a very specific way of remembering positions and the sequence the moon changed in. Without a deeper understanding of the system their retention of the information could be lower. To replicate the post test at some point in the future relies on their memory. A deeper understanding would give them more mental 'handles' with which to retrieve and process the information.

During the development and testing of the second multimedia program, a number of colleagues were asked to work with the tasks in order that the program could be debugged and checked for any problems. These adult users did not rely on the activities of associating pictures with positions and determining a sequence, (though these strategies were probably at work to some extent). Instead they were more concerned with thinking through the problem using visualisation and following light from the sun. This thoughtful method did not enable them to complete the tasks any quicker: in fact they took more time to attain enough score to finish. It is hoped though that such an approach would give them greater understanding of the system. Indeed these users were probably aware that there were easier methods by which to

complete these tasks, but as more experienced learners they chose to gain as much as possible from the program.

Since these observations were made during program construction they do not constitute formal results. However they indicate how a different type of user makes different use of the same material. This is an area which could be looked at in further study.

5.4.7. Deep and Surface Level Approaches

The pilot testing with subjects from the university and the actual empirical data collection at the school revealed two types of approach to the material. These approaches are similar to the deep and surface level approaches as defined by Marton & Säljö (1984). Surface level or atomistic approaches are those that “focused on the text in itself or on what the text was about”. Students with this approach were more concerned with memorising details and had a lack of orientation towards the message as a whole. The deep level, or holistic approach is characterised by learners considering “the author’s intention, the main point, [and] the conclusions to be drawn” (Marton & Säljö, 1984)

The deep approach in Phase 2 could be seen in the learners who identified the aim of the task as being one of understanding more than before, and who acknowledged that this change in understanding is their own responsibility. The learners at the university who completed the program by way of software testing worked in this way. These learners were more experienced and accomplished learners, who perceived the task as one of learning the content using the program.

The surface level approach was seen in students who interpret the purpose of the task as simply being one of completion. It is these learners who desire to simply finish the set task as quickly as possible using the easiest method. It is likely that they believe that this is all that is required of them, and by completing the program they have fulfilled their responsibility. Their main efforts, then, are put into completion of the task and learning is a side effect of this. The program may try to guide these students towards learning the material itself as the program in this study did, but the students may still be able to identify their own targets for learning.

Perhaps where Phase 2 succeeded over Phase 1 was in the level of involvement which the program required the students to enter into in order to complete the program. In Phase 1, the students could reach the end and complete the program with as much, or as little, mental effort as they wanted to invest.

Q: Do you think many people who were given a chance to do what they like , they would do very little?

Simon: You'd have to have someone to slave drive you

Q: So you need more motivation.

Simon: Yeah

Q: Do you think knowing they'd get such gruelling questions at the end would help, or do you think you should have someone watching over them

Simon: even though you did it, you're still going to get people who like, don't

The motivation to learn anything at all, for some students, was the knowledge that there was to be a post-test at the end. ThePhase 2 requires the students to be involved with the subject matter in order to complete the program.

5.4.8. Future Development of the Program

Although Phase 2 did improve effectiveness over Phase 1 there are still areas that need further development and research.

Consideration must be given to ways in which it would be possible to encourage the students to think in depth about the subject of the program; in this case, why the moon changes phase in a three dimensional manner and to consider the path of the light from the sun onto the moon. A task which required students to think in such a way would be more effective. Design of such a task is not trivial. It was hoped that the task in Phase 2 would achieve this. It is probably true to say that if there is an easier way of completing a task then many people would take that route. The learners could have been encouraged to think in terms of how the system worked if the program had presented them with animations and exercises involving perspective representations of the system. Ideally the students would be allowed to choose their own view point of the system in action, and would see the animated flight path (as if seen from the cockpit of a space craft) between key views so that the relationships between an outside viewpoint and various views from earth could be easily seen.

5.4.9 Summary of Design Features for Learning Effectiveness

In summary from the discussion above design features that have an impact on learning effectiveness are:

The use of interactive tasks where the user is involved in an activity that requires them to think in terms of the program's objectives.

Clearly stated goals so that the users are aware of what to do, and clear program structure so that students are able to be confident in controlling the program and their learning.

Positive program feedback that allows users to learn from their mistakes.

Testing of the program to discover user misconceptions and alternative unproductive ways of completing program tasks.

These general points are discussed in more detail in Chapter Seven.

Chapter 6: Video in Multimedia - a New Grammar

6.1. Introduction

From the discussion of how a student learns from educational video in Chapter One and the issues raised in re-purposing the video in Chapter Four, it is clear that the production of video for multimedia and the production of multimedia itself is quite different from existing media. Because it is important to consider the ways in which meaning is created in multimedia certain interpretations of multimedia come about. This chapter looks at the role of grammar in creating meaning, and how grammar operates in multimedia.

By looking at how the grammar of the familiar media of film and television operates it should be possible to learn about the grammar of multimedia. First the chapter looks at the definition of grammar and why it might be necessary to consider the interpretation of media in such terms. The chapter then goes on to look at some areas which demonstrate the need for a 'grammar', and to discuss the implications of this for integrating video into multimedia and for the design of educational multimedia.

6.2. Description of Grammar

This section takes a look at what is meant by a grammar. It begins by considering some definitions of grammar and then looks at some examples of how grammar works in television and film.

There seems to be no formal definition of a grammar of film and television. The existence of a grammar is commonly acknowledged amongst film makers, but there are few texts that deal in much detail with its description. In the absence of any existing formal definition, it is necessary to begin by constructing a working definition for use in this chapter which is quite broad. A formal definition of grammar for text is:

Art and science dealing with a language's inflections or other means of showing relation between words as used in speech or writing, and its phonetic system, and the established rules for using these. (Concise Oxford Dictionary, 1979)

It is therefore the means by which words are combined and interact in order to make meaning. Or more generally, it is a set of rules and guidelines for creating a structure in order to give meaning.

If words are the building blocks of written and spoken language then perhaps pictures are the basic element in film.

“Most pictures are factual, showing subjects in a familiar undistorted fashion, without any predominating emotional appeal. Yet, by judiciously arranging the same subjects, by careful composition, and a selective viewpoint you can modify their entire impact and give them quite a different implied *significance*. *You interpret the scene.*” (original emphasis) Millerson (1990).

Thus, the structure given to the basic elements provides their meaning and defines how they are to be interpreted. It is the process of production and presentation that elicits a certain interpretation of that picture. Indeed, as discussed in Chapter 2, even the process of taking a picture encodes the reality that it represents by imposing a particular structure upon it.

Words are ordered into sentences, and sentences into paragraphs that construct the written argument of the author according to the rules and conventions of writing. Likewise, television production captures carefully prepared scenes on tape, where they are edited together to form the argument of the video producer, using the conventions of video making.

It is these conventions of the grammar of a medium that structure the elements such as words, pictures and sound into a meaningful message.

We are familiar with the process of learning a language, spoken or written. An infant learns spoken language and then later learns to read and write. This learning of the mother tongue takes years and we know how difficult it can be to learn further languages. How and when do we learn the language and the grammar of film?

Film is an audio visual medium, and much of our view of ‘reality’ is perceived on audio visual channels. We are all experienced in interpreting sight and sound, so film is congruent with our own internal representation. It is necessary to develop the ability to recognise and interpret our surroundings at an early age. This is separate from learning the ability to follow the language of film: “children are able to recognise objects in pictures long before they are able to read, they are eight or ten years of age before they can comprehend a film image the way most adults do” (Monaco, 1981).

Monaco (1981) cites work by the anthropologist Willam Hudson to further support the idea that we have to learn how to perceive an image. Hudson studied rural Africans who had had little contact with Western culture. He tested their ability to perceive depth in two-dimensional images the same way in which Westerners can. He discovered that since they were not privy to the conventions of three dimensional drawings that are established in our society, they were not able to recognise the implied depth of either drawings in figure 6.1. Westerners are able to perceive depth in the first diagram and not in the second which has been rotated by 45 degrees.

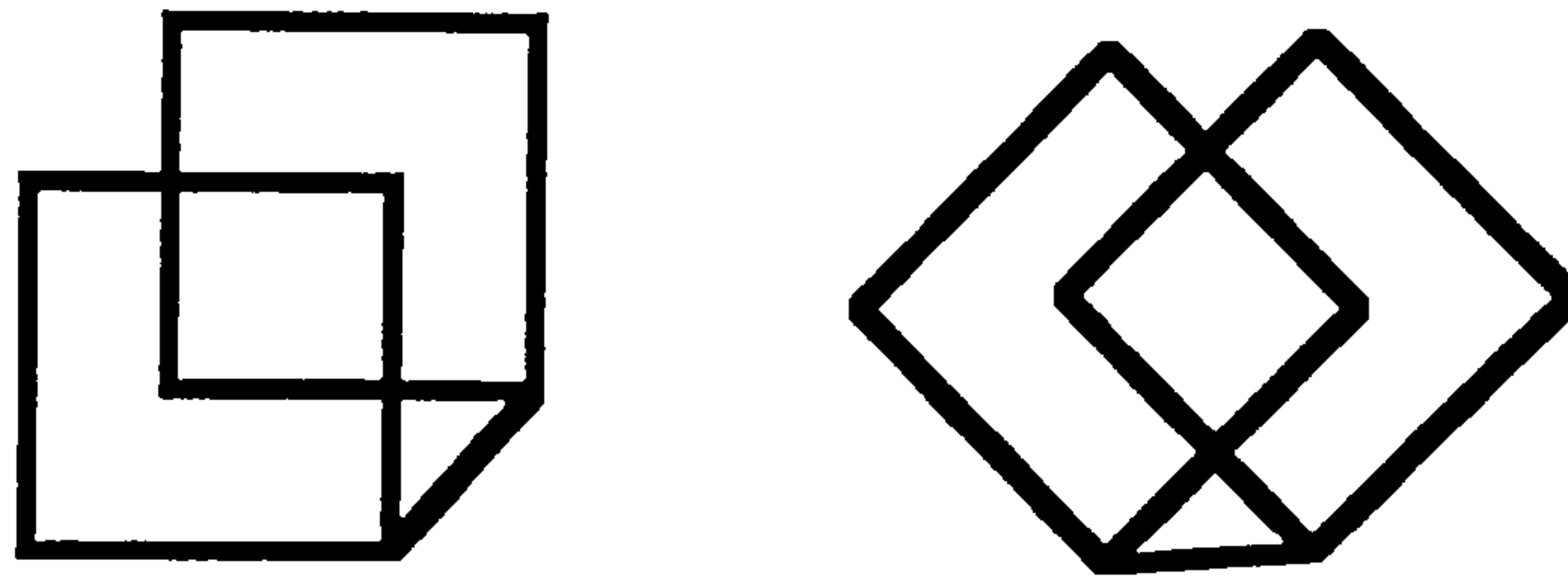


fig 6.1 diagram (a) is interpreted as 3d, but (b), though the same shape rotated, is not. (Monaco, 1981)

Similarly our understanding and ability to read film is based on our experiences with film from an early age - learning the existing conventions. These conventions are not learnt explicitly. Metz (1974) points out that we understand film not because we know how it works, but we understand how it works because we can understand film.

Before we look at the role of a grammar or language of multimedia it would be useful to take a look briefly at the language of film to see how a narrative is created and how ideas and impressions are represented.

6.2.1. The Grammar of Film

As with any language, communication takes place on the level of symbol systems (Salomon, 1979). Being unable to exchange experience or understanding via some sort of direct linking of minds we must communicate on the level of commonly agreed signs. A sign may be a spoken or written word, a picture, or even an action such as a gesture. From the point of view of semiology, a sign must consist of two parts: the signifier and the signified. As an example, consider the word 'book'. The word itself (the collection of letters, or the sound) is the signifier and represents the signified - the actual book. The signifier and the signified are almost the same in film. The picture of the book represents the book. The signifier and the signified have a direct relationship, whereas the word 'book' only has a symbolic relationship to a book.

This direct relationship makes film easy to read. Though since this interaction is much more natural than the more formally agreed and symbolic language of the spoken or written word, it is harder to explain.

Unlike written or spoken language, film has no identifiable smallest unit. In written language a letter is the smallest unit; in spoken language the phoneme. These combine to make words, words make sentences and so on. A shot in film is not the smallest unit since a shot encompasses time, movement and many elements. Neither is a single frame, since like a photograph it contains a potential of an infinite amount of visual information. Film, then, is not composed of units, but is a continuum of meaning.

Monaco (1981) suggests that film has no grammar. However, he only rejects the term in favour of another: syntax. He admits there are “vaguely defined rules of usage in cinematic language” and defines the syntax of film: “its systematic arrangement – orders these rules and indicates relationships between them”.

Film makers are quick to reject the idea of a set grammar of film. Such a set of rules could not be defined because of film being more congruent with our own internal representations than purely symbolic. Metz (1974) observes of film language: “One must be something of an artist to speak it, however poorly. For to speak it is partly to invent it.”. There are guidelines and some rules, but it is the film maker who must decide how to make a point in film.

The grammar of written and spoken language can only deal with the sequencing of words. Film grammar includes spatial composition.

6.2.2. Mise en Scène

A further set of variables that must be considered by film makers during the production of a film falls into the category ‘mise en scène’. Mise en scène refers to the elements that take place in the scene, such as lighting, costume, make-up, movement, direction of actors, gesture etc. In other words anything that comes in front of the camera. The amount of variation at this level is endless, but includes such ideas as: creating depth by using a moving camera; creating off-screen space by having actors reacting to off-screen activity; creating intimacy by using a big close-up; matching the lighting or colours to mood, etc. In controlling the mise en scène the director stages the event for the camera.

Bordwell & Thompson (1986) divide mise en scène into four general areas:

Setting

Costume and Make-Up

Lighting

Figure expression and movement

Quoting Bazin (1958), Bordwell & Thompson write about setting:

The human being is all-important in the theatre. The drama on the screen can exist without actors. A banging door, a leaf in the wind, waves beating on the shore can heighten the dramatic effect. Some film masterpieces use man only as an accessory, like an extra, or in counterpoint to nature, which is the true leading character. (Bordwell & Thompson, 1986; 122)

The setting, whether it is a carefully designed studio set, or a specially chosen location, is of the utmost importance in defining the whole character of the film. The setting is obviously chosen to match the narrative of the film, but the director has a lot of control over the exact look of the scene. Every element in the setting suggests something about how the viewer is to

interpret the film. The viewers' impression of the characters and events is largely influenced by the setting in which the narrative takes place.

The Glasgow University Media Group (1976) notes the effect that setting can have on news interviews. The striker on a picket line is interviewed in the cold outside, but the employer is interviewed in his / her office behind their desk. The setting of the boss gives much more authority to their argument (sitting behind a desk almost like the news reader) compared with the striker who is portrayed as 'the man on the street'.

Composition is coupled with setting. The director chooses the camera position and angle, along with the layout of the set or location, to draw attention to certain elements and to create a certain overall impression. Millerson (1992) notes of composition: "You can compose a picture to create anticipation, unease, apprehension, excitement, restful calm."

Similar to the selection of setting is the selection of costume and make-up. These are controlled to give us clues to how we are meant to view the character. The selection of the actor and the use of costume and make-up can be used to create recognisable stereotypes that the viewer uses as a basis for predicting how this character might behave.

Lighting in cinema controls the impact of the image. Lighter and darker areas help to create the composition of the shot and can guide the viewer's eyes to certain objects or actions. A darkly lit scene hides detail and can create suspense since the viewer cannot be so sure of what is on screen. The proper lighting adds depth and realism to a scene. An immaculately built set will be unconvincing if the lighting does not match.

Lighting plays a role in the production of meaning in television news. In the studio, the presenters and guests are normally lit to avoid any embarrassing shadows, but guests who have not been able to make it to the studio and so have been shot in some small regional studio, are not lit so kindly, and are often seen against unflattering backgrounds (such as curtains). The guidelines for televising parliament insist that all sides of the house are lit equally. If it were not so, members that were in greater shadow would look less trustworthy.

The director also controls the expression and movement of figures in front of the camera. The viewer's interpretation of the movement of actors is based on the interpretation of people's expressions and movements in everyday life. Though, in front of the camera, rather than happening naturally, these movements need to be considered and acted explicitly to suggest a certain reading by the viewer. The most natural looking film sequences are normally very carefully thought out and controlled. Even the interpretation of what appears 'natural' on screen is a convention. A comparison of realism in the 1980's against realism in film in the 1950's reveals very different styles - both considered realistic at the time.

Mise en scène is derived in part from processes of interpreting our surroundings that everyone carries out as part of life. What film has been able to do is extend the use of these existing interpretational skills in order to prefer specific interpretations of a scene over others. Such interpretation is based on an understanding of existing cinema codes and our own cultural make-up. An educator who wishes to use multimedia to suggest a particular interpretation will need to consider what the mise en scène of multimedia comprises of now that there is more than just video on the screen.

6.2.3. Editing

In this section I will talk about editing, and in doing so, will refer to both the director who provides the shots that are filmed and the editor who selects the shots that are in the final film cut. The director's and editor's role are complementary in constructing the narrative.

One element of film language that is under the film maker's control is montage or editing. There are two ways that editing is used. One way is to create seamless transitions from shot to shot, used to concentrate attention on the action. This editing avoids cuts that disrupt the flow of action, whereas good edits are the ones that go unnoticed. This seamless editing even works over cuts that eliminate a section of action. For example, a person may be seen to enter a building then a cut shows them arriving at a desk: a whole sequence has been omitted, but still the cut looks smooth.

Bordwell & Thompson (1986) describe four different types of edit:

1. Graphic relations between shot A and shot B.
2. Rhythmic relations between shot A and shot B.
3. Spatial relations between shot A and shot B.
4. Temporal relations between shot A and shot B.

Graphic and rhythmic editing are often used to create a smooth flow in a narrative and to maintain the viewer's interest and attention.

It is normal for an editor to establish the spatial relationship of characters and the location in the viewer's mind near the start of a sequence using a wide shot. Closer shots are then easily related to the position of the whole afterwards. Should characters in this space move, or new characters arrive, the editor will often use another wide shot to re-establish their relative positions.

An editor may change spatial relationships using editing. Locations that may be many miles away or from different times may be edited together to create a spatial relationship that did not exist before.

It is normal practice in film to record both sides of a single conversation at different times, and later edit the two films together to give the illusion of the camera switching between the parties as an observer might look from one person to another if they were there.

Spatial editing can be used to relate events as cause and effect that were shot at separate times and places. For example, a news report might show a cannon fire, then cut to a shot of a shell hitting its target, implying that the shell being fired is the one that is seen landing, which, of course, is very unlikely.

Bordwell & Thompson (1986) report the Soviet film maker Lev Kuleshov's experiments in creating spatial relations. Kuleshov intercut a neutral shot of an actor's face with shots of soup, nature scenes, a dead woman and a baby. The audience believed that the actor's expression changed, and that he was responding to things that were present.

An editor may alter temporal relationships in a film. An edit may take the viewer backward in time to a flashback, or alter the sequence of a number of events. Parallel editing can be used to intercut two events that are happening at the same time. Elliptical editing enables the editor to present an action that takes less time on the screen than in the story. There are three ways that editors can lose time like this. The most common is the use of the *cutaway*, in which the editor cuts to another shot that does not last as long as the action that has been cut from. When the film returns to the first shot the action has finished. In an example of a man climbing a set of stairs we would see him start climbing the stairs, cut to someone waiting in a flat on the top floor, cut back to him arriving at the top of the stairs. A further way of losing time in this example would be to use *empty frames*. This time the man climbing the stairs walks out of shot leaving the screen empty, the editor then cuts to another empty frame of the top of the stairs that the man enters into as he reaches the top. A third way of losing time is to use some form of conventional *punctuation* such as a wipe or dissolve. An editor would dissolve the shot of the man starting his climb into the shot of him finishing this action.

A less common way of altering temporal relationships in a film is by expanding the on screen time so that it lasts longer than the actual action. The same action is seen from different angles, each new cut overlapping some of the action already seen. Or returning from a cutaway to either see some of the action happen again or having been on the cutaway shot for longer than the action would have taken to complete. This expansion of time can be used to create tension as it can be used to delay or expand a dramatic moment.

This manipulation of time is essential in creating a narrative, since few films' on screen time matches the story length.

The power of editing comes from the notion that adjacent shots combine to make a meaning that neither of the shots had on their own. This is done either by creating a juxtaposition, or by drawing a parallel between similar movements (of the camera or action), or other similar *mise en scène* elements (such as similar objects, lighting, sounds etc.). By matching elements over the cut, the editor can often make a smooth cut that covers a very long time, or suggest a connection in order to make a point. In Kubrik's 2001, a primitive man hurls a bone spinning into the air, and this picture matches the shot that is cut to of a spinning space station of the future. Not only is the transition smooth, but it also draws attention to the evolution of man's tools from bone to space station.

There are a number of conventions which relate to continuity editing that are used to build a narrative space and to encourage an agreed reading of the film. For example, in a sequence where a couple meet and start talking, we would expect to see an establishing shot at the beginning, and as they talk the camera should cut to the person who is talking, or to the listener to see their reaction. As the conversation becomes more involved the editor will use closer shots of the actors to heighten the involvement of the viewer, or use a slow zoom in to signify growing interest in the topic (a technique often used in party political broadcasts). Extreme close-ups where the camera invades the personal space of the actor are used to heighten the emotional content, such as anger or distress. If there is a natural break or lessening of tension then the editor will start using wider shots again.

The *180° rule* is used to create and maintain narrative space. Shots are used which are all taken from one side of an imaginary line through the scene. By following this convention, cutting between people always maintains the direction of their gaze and so also their positional relationships. To break this rule and cut to the other side of a person would make them appear to face a different direction, or to cut to the other side of an action (such as someone walking) would make it seem as though the action changed direction.

In order that the viewer does not recognise or notice the technical aspects of the film, continuity editing relies on narrative motivation for all of its construction decisions. Each cut is motivated by an action in the scene, a sound, some one talking, or the need to see someone's reaction. The idea that the film's construction is motivated by the narrative is reflected in the adage "if it's in the shot then it's in the plot". If other elements are allowed to dictate an edit then the viewer's attention will be focused away from the narrative on to something that is unrelated to the film's progression. Such elements act as 'red herrings' and confuse the narrative and the viewer. For example, if the editor were to leave a shot of an actor on screen for even just a few seconds longer than was necessary for them to fulfil their role in the plot,

the viewer is likely to interpret this as having some significance -- what's the actor thinking? Are they having second thoughts about what has just happened? Maybe he's planning his revenge...

Such conventions are used abundantly in modern narrative film and television, though at any time the director may choose to disregard any of these conventions for dramatic effect or to deliberately mislead the viewer. If the director were to disregard many of the conventions though, the film would soon begin to lose its socially agreed meaning.

Editing can be used to manipulate time (shorten or lengthen), show parallel action, suggest spatial relations, suggest additional meaning through juxtapositions and denote flashbacks / forwards. The fragmented non-sequential nature of multimedia video will mean that editing video in multimedia will be very different, this contrast is taken up in section 6.3.3.

6.2.4. Sound

It is easy to overlook the role of sound on film as simply that of accompanying the moving images. As Bordwell & Thompson (1986) demonstrate with a sequence from 'Letter from Siberia' by Chris Marker, sound in a film can "actively shape how we interpret the image". The sequence repeats the same four shots three times, each repetition accompanied by a different sound track. The commentary for each gives a completely different interpretation of the pictures, men that were working in the "joyful spirit of socialist emulation" on one commentary were "Bending like slaves" in the next. A viewer presented with either commentary would have little reason to doubt the description of the pictures as accurate.

Sound in a film can also direct the viewer's attention to something in the image. A viewer will try to find the relevance of any image to the narrative and will soon pick out a known character from a crowd on the screen. Similarly sound can direct the viewer's attention to what they should be looking at on screen. If the picture of a crowd was shown and the commentary said something about children, the viewer would automatically think "ah - it's children that the narrative is talking about" and begin to pick out the children from the crowd.

Sound has an active interaction with the film image and narrative. Bordwell & Thompson (1986) use the example of a close-up of a person with the sound of a creaking door off-screen- the person looks up. If the next shot showed the open door, viewers would focus their attention on that. Or perhaps if the next shot showed a person in front of the door - they must have just entered. Or if the next shot showed a closed door then the viewers would ask themselves what the sound was. This way the sound has focused attention, clarified an event, or rendered an event ambiguous.

The sound of the door creaking would create the expectation that someone had entered the room. The viewer would expect the next shot to show who, but the director could stay on the shot of the man looking increasingly alarmed thus creating the impression something sinister is off-screen and creating tension. Even silence can be used for dramatic effect in film.

The correct sound adds depth and atmosphere to a scene (e.g. wind whistling or birds singing). Sound can be used over edits to make a relationship between locations (e.g., cut from loud party to darkness outside with muffled music some distance away). There are many possibilities. The role of sound in multimedia is examined in section 6.3.9.

6.2.5. Narrative

The discussion of mise en scène, editing and sound have shown how sequences can be constructed to contain a specific meaning. For a film to contain an overall story or function it is necessary to consider narrative.

Bordwell & Thompson (1986) define a narrative as "a chain of events in cause-effect relationship occurring in time and space". Monaco (1981) describes a narrative as "the linear, chronological structure of a story".

Recounting a sequence of related events is not enough to make a narrative. The events and descriptions that are described must all add to an understanding of the story, and the story itself must normally have some structure. Todorov (1977) expresses such a structure in terms of a transition from a stable state to a disruption and then resolution.

Lamarque (1990) highlights the structural function of narrative:

Narration of any kind involves the recounting and shaping of events. Description is not enough. A mere catalogue of descriptive sentences does not make a narrative. Narration has an essential temporal dimension. ...the events must be shaped or ordered. Narrative imposes structure; it connects as well as records. (Lamarque, 1990; 131)

Almost all films and television programmes use narrative as their formal system. That is they have a sequence of events, usually in a cause effect relationship over a period of time, and they structure the telling of this story using a beginning, middle and conclusion.

Metz (1974) observes that a narrative has a beginning and an ending, a fact that distinguishes it from and opposes it to the real world. While the story of a film may reference events that are not seen, the film's narrative is enclosed.

Though most of the work on narrative, both of film and text, deals with a fictional narrative, a narrative need not be fictional. Most educational and documentary television or video fulfil the definition of a narrative. A typical educational video presents an argument rather like this: a concept is introduced, the need to know about this concept is often demonstrated, a

series of points that relate logically to demonstrate the knowledge follows and ends by drawing together the preceding argument to form a conclusion. This description describes the structure of the video used in chapter 4.

If the above ideas of *mise en scène*, editing are elements of a language of film that can be controlled to create a specific reading of the film, then I would like to suggest that conventions and guidelines that control these elements constitute the grammar of film.

6.2.6. Concluding Points

This section has discussed the concept of grammar in a medium and looked at how such a grammar is used to create meaning in film and video. The analysis of the S102 video in Chapter 4, using Koumi's (1991) framework of narrative screen writing for educational television, is a typical example of how the grammar operates in educational television. The next section considers how these issues relate to multimedia and demonstrates the need for a grammar in multimedia and investigates some of the issues involved. The issue of a grammar for multimedia is discussed with education in mind, though many of the points do not relate specifically to educational multimedia.

6.3. Aspects of a Grammar of Multimedia

The task of converting the video that was used in the Phase 1 programs from the original video-tape based form to a form that could be integrated into the multimedia was valuable and revealed some of the grammatical issues.

The video "The Planet Earth - A Scientific Model" formed part of the S102 science foundation course for Open University students, and was designed to be broadcast on national television. Some Open University videos are designed with off-air recording in mind and are designed so that a student may start, stop and review sections. This was *not* one of the considerations for this video, because it was produced as broadcast television so that it could be watched in real time (though recording is always a possibility).

The two multiple media versions of the programme were to keep the same content, though one was designed to keep the same structure and accessibility, and the other was to add hypertext / multimedia features to allow easier access and an explicit structure. It was originally hoped that both versions would contain most (if not all) the original video, and would simply alter the way of accessing this material.

During the creation of both versions it became increasingly obvious that such a straightforward conversion was not sensible, nor in some respects possible. During the design

process it became clear that some elements of the video could not be converted to multimedia format. Some had to be altered and others could reasonably be left the same.

It is this mismatch between the video and multimedia formats that helps to illuminate the different 'grammatical' properties of the two media. This section discusses each such issue in turn.

6.3.1. Role of the Presenter

Presenters are found in almost all educational video and television. They serve a number of useful functions, especially in documentary or educational programmes. A presenter is important because there are no actors whose dialogue and actions can construct narrative to make the point for the programme. Educational and training programmes may include acted sequences. TerminalRISK in chapter three is an example, as well as John Cleese's management training videos. However, these videos tend to have acted sections still linked by some form of presenter (even if only a voice over).

The term 'diegesis' in narrative film is the world in which the film's story takes place. It not only includes the events that have happened on screen but also other events that are presumed to have occurred and actions and spaces not shown. Citing Nichols (1981), Plowman (1993) says "whereas the appearance of a narrator speaking in direct address almost invariably ruptures the diegesis of fictional narrative, it can *constitute* the diegesis of documentary exposition". Presenters in educational video guide and shape the narrative, first introducing the programme, and then linking subsequent sections until summing up at the end. In this way they form part of the diegetic space rather than disrupting it. During the programme's sections the presenter may well be seen describing the argument as a lecturer might - but being able to use the location, and cutaway sequences as resources. This is how the S102 video in Chapter 4 was designed.

The presenter is also used to introduce other people, such as experts in the topic, into the video. Often the presenter will not be an expert in the subject themselves, but instead they are seen to stand between the expert and the viewer. Rather than have these experts explain their complex knowledge directly to camera, and so directly to the viewer, the expert will look at the presenter as they make their argument. The presenter will often ask questions to guide the expert and to clarify points.

Presenters in this role are like agents for the viewer, asking questions on behalf of the viewer and having them explained to them. The presenter will make conclusions based on the what the expert has said on behalf of the viewer to so that the viewer can follow the line of reasoning. For example the presenter may say something along the lines of "so if X and Y are true what are the implications for Z?...., I went to the London Institute to ask Dr. Smith...."

The presenter not only acts as the viewer's agent by mediating between invited experts and the viewer, but also can be a substitute for the viewer's experience. Rather than just seeing a location or an event, seeing the presenter in that location or at (or taking part in) an event can help give an extra dimension to that event. Throughout the programme the viewer builds some relationship with the presenter and the presenter's reactions and experiences can be used to enhance the viewer's understanding. Of course, the presenter's reactions to an event may be controlled so as to prefer a specific reading of a scene.

Though it is unlikely that the presenter of a programme is solely responsible for writing the programme's script, it does appear to the viewer that the presenter is in control of the programme direction, having the power to decide how the programme unfolds, and what points are important and are to be examined. This power gives the presenter some authority. The viewer can either follow the path that the presenter shows, or become lost. The viewer does not get the chance to question or interrupt the direction of the presentation, or say "I want to hear more of that" or "shouldn't X be considered?". If the viewer does not follow the presenter's argument then they will not be able to follow the programme - this does not mean that they must accept the presenter's position; only follow it.

What about the role of the presenter in multimedia? The traditional use of the presenter in video is altered for multimedia. In converting the existing educational video into a multimedia version it was very difficult to include any of the original presenters either as links or as an agent.

The presenter's links between sections and within the sections when they were explaining a point are difficult to include. The modular nature of video in multimedia means that sections of video are linked not by video, but by other elements in the multimedia (video sections linked by video would be a continuously running video). The need for a presenter to link sections has been removed.

The use of the presenter as the agent of the viewer has changed too. It is possible to still use the presenter to introduce and interview filmed experts on the viewer's behalf in video sections, but the relationship with the presenter has changed considerably. No longer is the presenter a figure of authority deciding who to talk to, guiding the viewer through the material, with the viewer following the presenter's argument in order not to get lost. This time the viewer has control over passage through the material, and has the ability to stop and start. The presenter seemed weak and so what they were saying less important. A textual description accompanying the video demonstration seemed to work better.

The presenter in multimedia does not have as much power to shape the narrative. The role of a traditional presenter in moving the argument along and steering the viewer through between points, revealing what is necessary when necessary, is gone. The presenter can only

suggest a route, and the viewer must have a clear idea of the program structure and aims in order that they can navigate the domain in a way that best suits them.

Designers of video for multimedia may decide not to use a presenter, but may still want to include 'talking heads' video of experts in the subject. If they were to do this then the experts would no longer be able to talk to someone off camera. If they were to look to one side of the camera while talking, the viewer would wonder who they were talking to. The solution must be to have the expert address the camera, and therefore the viewer, directly. Existing video grammar only allows a few people the privilege of direct address to the camera. Anyone who is able to look directly at the camera while talking is seen to be a 'bearer of truth'(Hood, 1980). These people are normally news readers and topical programme presenters, but this category also includes the monarch, the prime minister, cabinet ministers (when they make official broadcasts), the leader of the opposition, the archbishop and comedians. Any one else has to talk to the presenter and not directly address the public. The presenter intercedes for this person. If this person takes the initiative and addresses the camera, say in a live programme, then the director will cut away to the presenter.

The control of the video in multimedia, deciding who you want to see, and having these people directly address you negates the need for a presenter and may be of benefit in education. On the other hand, now that the presenter no longer has any authority in defining the narrative and guiding the viewer, the viewer may have a weaker relationship with the presenter so that the viewer does not benefit from the experience. This might explain why the presenter seemed weaker when transferred from the original video. Does this mean that presenters in multimedia are redundant? The use of a presenter in the video sections is still useful, though in this new role with less authority the presenter becomes more of a servant to the learner. The presenter can still be used for many of the functions of existing video and has the ability to directly address the learner, to introduce sections, to give help and guidance, and to ask them questions.

Perhaps the ability of the presenter to shape and add coherence to a video may be extended to multimedia. Plowman (1993), in her study of a language interactive video disk for children, notes that the presenter offers some visual and narrative continuity. If the presenter can be used to do this, then in a medium where there is danger of disorientation and fragmentation this would be particularly valuable.

Filming and construction needs rethinking for the new role of the presenter in multimedia. The success of the presenter will depend on careful design and filming as well as consideration of the above points.

6.3.2. Who is Author

The question of 'who is author of a studio-produced film?' has been argued and debated for some time amongst film critics. The interactive nature of multimedia adds new dimensions to this contention.

Bordwell & Thompson (1986) suggest the confusion arises from there being three definitions of authorship in film: author as production worker, author as personality and author as signature on a group of films.

Much of the argument lies in the 'author as production worker' definition. Is the director, editor, scriptwriter or screenwriter the originator of the film's message? The argument is complex and inconclusive. Moreover, for educational multimedia a number of other people may be contenders for author: executive producer, producer, academicians etc.

Author as personality suggests that the author of the film is the originator of the personality of the film (this normally is credited to the director). The Alfred Hitchcock personality for example is suspense but also brooding Catholic guilt.

The notion of 'author as a group of films' occurred as a response to those who advocated personality as author. Some critics looked to group films by signature of director, producer, screenwriter etc. The author was no longer a person but a system of relations among several films bearing the same 'signature'.

In multimedia, the question of authorship is even more complex. We have already discussed the authorial role of the presenter: the presenter seeming to have authority over the revelation of, and route through, the argument in video. In multimedia, the presenter loses this authority since he can no longer control the learner's viewing or use of the material. It can be argued that learners are the authors of their particular multimedia experience since they are the originators of their particular thread through the material, constructing their own goals and routes. The presenter can only act as an adjunct to the learner's progression through multimedia.

This ability to be responsible for the production of your own interpretation of a medium is discussed by Fiske (1987). Fiske differentiates between two sorts of text: one that is closed or *readerly* and the other that is open or *writerly*. A readerly text is one that hides its construction and promotes a singular meaning by being produced through "standard representations and dominant signifying practices" (Silverman, 1983). Popular fiction is considered to be a readerly text. A writerly text does not attempt to close off alternative meanings and narrow its focus to one easily obtainable meaning, but instead is open to a rich diversity of readings. Writerly texts often are considered avant garde since their construction does not allow a simple reading and the reader is forced to consider the text's production. A

writerly text replaces the readerly concepts of “product” and “structure” with “process” and “segmentation” (Fiske, 1987: p.94). While holding for other text television does not fit cleanly into either readerly or writerly categorisations. There is a conflict, since on one hand it is readerly in that it relies on standard representations and conventions in signifying, but on the other hand its semantic richness and its need to be popular and appeal to a diverse audience force a degree of openness. Television is polysemic - it promotes many different readings of the same text.

Fiske (1987) notes the ability of television to promote multiple readings. Each viewer is the author of their own interpretation:

The writerly text, which the television text often is and always can be, requires us, its readers, to participate in the production of meaning and thus of our own subjectivities, it requires us to speak rather than be spoken to and to subordinate the moment of production to the moment of reception. (Fiske, 1987 p95)

Fiske introduces a new term for this type of text which is popular but still writerly - *producerly*.

Educational television and video, especially when produced for a known audience of students, strives to be readerly since often a specific interpretation is desired.

Multimedia must be even more open than video since it allows the user to make explicit links that the author had not previously considered. The construction of multimedia is more obvious to the reader than the construction of television, and is not deliberately hidden. Writerly texts often rely on contradictions and “work with an authorial voice that uses unfamiliar discourse in order to draw attention to its discursivity” (Fiske, 1987: p.94). The avant-garde author shocks the reader into reading at a meta level where they must learn new discursive skills if they are to participate in a writerly way to gain meaning and pleasure.

Multimedia does not have to rely on such techniques in order to be a writerly text - learner control already does this. This control requires the learner to keep track of the structure and as Mayes, Kibby & Anderson (1990) observe ‘getting lost’ in a hypertext type structure forces the user to spend effort in the meta-level activity of mapping the information they discover onto their own framework of understanding. It is possible then to relate a complexly structured hypertext to an open or writerly text that requires the learner to be aware of the structure of a text.

The degree to which multimedia is open or closed must depend on the freedom that the user is allowed. It is conceivable that in education the multimedia producer may work to limit the learner’s freedom so that they consider only a very narrow area. It is also conceivable that the learner is given access to a wide variety of audio, visual and textual resources and

activities and is allowed to chart a course through the material that best suits them within the confines of the learning goal.

Säljö (1984) observes the responsibility of the reader of printed material:

In comparison to oral communication the written discourse thus implies a different distribution of responsibility for controlling the progress of the 'dialogue'. Once writers have encoded their message, it leaves their charge: reconstructing what is made known is at the discretion of their readers.
(Säljö, 1984, p86)

The same observation must apply to any text which is read in a situation where the author cannot respond to the users' (mis)interpretations. For the user to fulfil this responsibility of reconstructing the original argument they must be prepared to provisionally accept the line of reasoning presented by the author as they are reading, even if it is contrary to their own views. The "reader / learner must grant to the writer the active role in directing the dialogue, provisionally accepting the premises the writer has introduced" (Säljö, 1984, p86).

In a multimedia program that provides a strong narrative line and less user control, Säljö's analysis of the situation would still apply, but for a multimedia program that offers the user greater opportunities for developing their own learning paths and strategies the situation is somewhat different.

The author has not constructed such a well defined narrative line for the learner to follow. Instead the author of an interactive multimedia program has provided an environment through which the learner has control. Whereas before, the author provided a path that the learner could reject, but none the less had to follow, learners can now be given access to the learning environment created by the author. They have much greater control over how they interact and work in this environment. In many respects, the author of the narrative line that learner follows is not the program designer / educator but the learner themselves.

This type of multimedia may be suitable for some educational situations, but for the author / educator who has a specific message to get across to the learner this does not sound good.

Just as writers of printed text can carefully plan their texts so that a single interpretation is preferred (as discussed in 'Print' section of Chapter 2) so can writers of multimedia. If writers have a knowledge of the grammar of multimedia they may guide the learners towards certain interpretations. They can carefully select and edit information in the multimedia program, limiting aspects of user control or controlling the revelation of the material. After all the learner may be an author of their own narrative line, but it is a line through a narrative space that the educator has designed and set up. The adaptive capabilities of multimedia open up further possibilities that authors of other media are not privy to. The authors of multimedia, like other media, must relinquish control of their material when they publish it since they are not present when the reader reconstructs their message (Säljö, 1984).

Good writers try to compensate for this by anticipating the learner's questions and problems and including the solutions to these in the text. Multimedia programs can take this a step further since they may monitor student progress, or recognise particular misconceptions during activities, and so are able to adapt their teaching strategies, or offer remedial help.

The user, then, can be considered as an author of their particular multimedia session. However, they are not sole author as they have constructed their learning with the guidance and resources provided by the educator.

6.3.3. Linking Video Sections

From the discussion at the beginning of the chapter we saw that narrative in film and video is a series of events in a cause-effect relationship over time. As with any argument construction, if the events have no explicit or implied relationship then they become a series of unrelated points. In such a scenario the reader has to determine the relationship between the points. Such a system can be found in the non-narrative associational film form, but is seldom used. Narrative lies in the construction of a whole. If video is to be segmented when included in multimedia how can a narrative whole be maintained? Either each video section has to be linked to each other across the other multimedia elements, or the video narrative has to link to the other multimedia elements sufficiently to form the complete narrative structure.

It is often the links that lie between sections that carry some of the most salient points of an argument, and are certainly essential for understanding the argument. During the conversion of the original video to multimedia it was possible to easily divide the original video into sections, and within those sections to sub-divide the argument further. Many of the sections or subsections included a video segment. The process of defining segments of the video was not very difficult, but there was a problem when it came to linking these sections.

As would be expected each section had some sort of link. For example, this is a typical link in the original video:

"So it seems reasonable to carry on this double view point approach to see if we can't explain some of those more peculiar phenomena that we see when we look out at the planets."

This links the section on the phases of the moon to the next section examining the retrograde motion of the planets. The presenter is seen as a head and shoulders shot for this link. Like any link, it is important to the development of the argument. Without it the section on the moon and the section on the planets would become two separate sections, and their overall relationship to the programme would be weakened. The link re-inforces the main argument of the video - that of scientific models and frames of reference, not an account of the moon

followed by an exploration of the solar system. Such a link does not fit easily, in its existing form, into multimedia. If the head and shoulders shot of the presenter was to be retained would it go at the end of one section, at the beginning of the next or at both perhaps? Would this link be a separate video module in itself, or be attached to the preceding or following video? The problem arises since the learner has control over the program, and chooses when they continue with the next section. Though video defines different sections to the viewer, it also has control over the links of these sections. The video producer can be confident that the viewer will go from one section to the next without pausing. The break between sections in multimedia is much more pronounced. The learner is more able to think "that is that section finished, now let's have a look at this new section" and so closing one section in their minds and opening a new one. In doing so the break in the sections is over emphasised and the link is disregarded. This problem is confounded by the learner's ability to make the break between sections as long as they like, and to traverse between sections in an order of their choosing.

It cannot be certain in which order the learner will work with the sections in multimedia, so linking is very different from video. As discussed in Chapter Two, it is partly the facility for the learner to move between sections as they require, working at the depth that they need to, and concentrating on sections of particular need or interest, that makes multimedia an interesting medium. Of course in education, the educator may want to make sure that some or all of their material is interpreted in the desired way, and that a particular argument can be understood. It is then that the links between sections are of particular importance.

For this reason, in the linear multimedia version the linking of sections was not so much of a problem. The video links for the sections were not used, but instead on-screen text contained the necessary information. The structured version presented a greater challenge, as the same textual links appeared at the beginning of the sections, but there was no guarantee that the learner would have seen the section that would have preceded in the linear version. To counter this, as a learner arrived at a sub-section (card), a spoken (audible) summary of the section was played. It was hoped that by reinforcing the key point of each card in this way, the learners would be enabled to see the connections between sections. Many of the spoken points specifically vocalised the connection between sub sections. For example, there is a spoken link between the section that shows the apparently strange motion of a pendulum swinging over a roundabout and the section in St Paul's cathedral where the motion of the earth is measured:

Spoken Link: The earth, like a roundabout rotates. Will we see similar effects on earth?

(This was played at the beginning of the section in St. Paul's)

Whalley (1993) is investigating a system which attempts to keep continuity between video segments . The system has a topic hierarchy that is used by the student to select sections of

the video. The hierarchy corresponds to the structure of the printed study notes. As the student moves down in the hierarchy the video fragments have different and usually more complex voice-overs to make up for the loss of contextual information that would normally be provided by the video's continuity editing. The system appears to work as a tool to study existing video or film, allowing the student to examine fragments of the film without losing their relation to the context as a whole. The principle could also be applied for video split across a multimedia program: each video section that the student watches could have a short introduction that would put it in context with the other video sections.

If video could link to other sections of the multimedia in a similar way that video sections link to themselves then perhaps the narrative could be carried seamlessly between the various component media of multimedia. New grammatical cues to do this would have to evolve over time, much as the grammatical cues that link and create meanings between edits within film did.

Continuity between sections and program points needs to be maintained in multimedia. A continuous medium like video does this with narrative and unbroken flow. A static user controllable medium such as print allows users to easily establish their position in the text. In multimedia where the users are defining their own paths through the material it may be difficult for the program to provide meaningful links between the sections and so provide continuity. In multimedia there is a greater demand on the user to keep track of their position within the program and within the argument line which they are pursuing.

Multimedia needs to help the user maintain an understanding of the position that they are in. This might be achieved by providing a coherent continuity of the argument through clear links, and by providing a way for the user to re-establish their position through a review of previously covered ground.

6.3.4. Narrative in Multimedia

Educational video uses narrative to make its argument. Like the other non-interactive media and teaching methods of lectures, print and audio educators must construct their argument linearly through a series of points. This linear story or narrative is delivered to the learner who follows its sequence.

Multimedia is non-sequential, so the educator is no longer in control of the revelation of the narrative. If we look at our original definition of narrative as "a chain of events in cause-effect relationship occurring in time and space" (Bordwell & Thompson, 1986), and as a linear chronological structure of a story in transition from disruption to resolution, we can see that it is still possible to apply these descriptions in some way to the interaction of the user with the multimedia system.

Even if users have a certain amount of freedom as they work with a tutorial system they are still working with a structure that was predetermined by the educator. They may be able to select their route and the level at which they work, but still they are working within the boundaries of the original designer's system. Also, they still take an essentially linear, though self-determined, route through the material, (see Whalley (1990) and Chapter One for discussion on the linearity of texts). Even printed texts have parallel argument lines and links to other parts of the text. Multimedia allows these links to be made more easily and under the control of the learner.

Cause and effect can apply in a multimedia narrative. Indeed cause and effect can be expanded to include not only the actions of on-screen characters, but of the user too. The cause-effect relationships of a film are set by the film's makers: the designers of multimedia may choose links to either have predetermined relationships, or to guide the learner towards certain conclusions and narrative elements. The outcome of a multimedia session could depend on the variety of material the learner sees, the sequence in which they encounter it, and their actions during it.

Learning materials should foster transition from a relatively disorganised to a stable state. Multimedia should be able to do this by supporting a progression from the state of the learner's knowledge at the beginning, through the creation of goals and the demonstration of the need to know the subject being taught, and then the discussion and linking of argument points, through to the conclusions. It should be possible for this type of transition to be characteristic of learning through Multimedia.

Multimedia allows some adaptation of the straightforward storytelling /narrative scenario. It is possible in an appropriately designed multimedia program that the user could follow a narrative laid out by the program's designers, in much the same way as they would follow the narrative in a book. The user determines the pace of their progression through the text, but the author has defined the logical route. The use of multimedia in this way has allowed little user control and is similar to the linear multimedia program from Phase 1 of the study, and is also similar to the way one would follow a narrative in a book. Film and video narrative allows even less user control since not only is it linear, but it runs continuously.

A properly designed multimedia program can extend the story telling capabilities of existing media. It is possible to allow the learner more control over the narrative by letting them explore some aspects of the narrative at greater depth while spending less time on others. In this way the user is allowed to ask questions of the storyteller such as "can you tell me more about this aspect?".

In a learner controlled narrative the user may have the option to choose how to end the interactive session, and at which point to leave the narrative. They also determine how

time is controlled during a narrative. The user can extend time in, or repeat a section or skip over and shorten narrative elements. This posed a problem during the conversion of the original video in the present study. The presenter, to demonstrate how Foucault's pendulum moved sideways as well as backwards and forwards, erected a pencil a few centimetres away from the pendulum's current path and estimated that the pendulum would reach that point in around quarter of an hour. The video then continues on to the next section. At the end of the video the presenter sums up the programme with the statement:

But we've always got to be prepared to put our imaginative ideas to the test.
And the real test of any scientific model is to see just how it stands up in the
light of experimental fact.

The video then cuts back to the pendulum in the cathedral to see the pendulum swing past the pencil once and then on the next swing hit the pencil and knock it over. This sequence demonstrates the scientific proof behind the models that the video dealt with. This image is a strong one, and is used as the very last image in the video before the credits role.

The actual time between the shot of the presenter erecting the pencil and the shot of it being knocked down is indeed about a quarter of an hour. If not exactly real time, the time lag does serve to emphasise the real nature of the model and to end the narrative poignantly.

Grammatical devices such as this that rely on either a specific sequence or timing are very much more difficult in multimedia.

Since the users of multimedia have greater control over the sequencing and interpretation of the program they can be considered to have some authorship over the narrative line. This idea is discussed in the section 'Who is Author'.

The analysis of the S102 video using Koumi's (1991) framework, in Chapter 4, demonstrates some of the complexity of educational television narratives. Each element is carefully selected to contribute to the overall interpretation of the video. Each sequence is a carefully constructed argument point that has considered the interaction of words, visuals, sounds, music, edits, pace, mood etc. and is linked to other points and so into the video's argument as a whole.

The narrative in an educational television programme, then, is a constructed whole that is delivered to the learner, not only consisting of distinguishable argument components, but of cues and hints to the desired interpretation. If a similar level and type of construction is to go into an interactive computerised narrative then a similar level of narrative construction will need to be built into the non video sections because the video sections and the links between, and user interactions must be encompassed as part of the narrative and must not be allowed to break it up.

6.3.5. Guided Discovery

The transfer of video from a linear format to multimedia revealed differences in narrative construction. The way that the narrative of an educational multimedia program is constructed will have to be different from the existing way that educational video narratives are currently constructed.

An educational video programme reveals its argument linearly. The educator deciding what is relevant at each point, leads the learner through an argument, linking each point with the next, until finally all points have been covered and the argument structure as a whole for the video is complete. Although the educator may set the learning goal of the programme at the beginning of the video, the learner will know little about the layout of the programme that fulfils this goal. The educator may decide not to confuse students with the full programme agenda, but reveal each successive point as it becomes necessary to know it.

In the 'Scientific Model' video from Phase One, the introduction sets out the idea that the video is going to examine the idea of understanding systems by looking from a different frame of reference. But the viewer is given no indication of how the programme is going to unfold or of what examples it will use. These are revealed only when necessary. The programme may even raise issues that the viewer is not expected to understand fully at that point, in order that it may later pick these points up. The learner is content in the knowledge that the programme will lead them through the argument. They also know the approximate running-time of the video and so use this as a prediction of the programme's progress. This is a natural part of video, but cannot operate in the same way in multimedia.

In multimedia, the learner is in control of their progress through the program. In order that they can make a personally valued decision about how to approach the work the learner needs information about the resources available in the program, approximately how long it will take to work with them, and how they fit together.

Such a scope of information and freedom would make the multimedia program into a resource-based program, where the learner searches and analyses the information according to tasks set by the teacher or by the program. As we discussed in Chapter Two, resource-based multimedia is problematic in that it relies on the learner having sufficient skills in searching and analysing the information. Designers need to be able to allow enough control of the media so that learners can use a learning strategy most appropriate to them, while allowing the program to offer guidance and remediation and to be adaptive. This is neither discovery learning, where the user must find their way through the material, nor guided learning where the program leads the user through the material. Laurillard (1994) describes this type of learning as being *guided discovery*. This is discussed more in Chapter Seven.

6.3.6. From Implicit to Explicit Construction

Continuity editing goes to great lengths to hide the construction of the narrative. Anything that might alert the viewer to how the narrative was constructed is avoided. If the viewer began to consider the technical aspects of the film's creation while watching it would detract from the atmosphere and illusion of continuity. It is important in film that nothing reminds the viewer of the production process or narrative construction.

It is necessary for the users of video in multimedia to have a greater awareness of the film's structure, since they can no longer watch the narrative unfold before them as in film, but have to select and control the sections.

This heightened awareness of the structure of the video must mean that a constructed narrative cannot flow in the same way in multimedia as before. If the video sequences in an educational media relate logically, an increased awareness of this structure could help the student to gain a better overall understanding of the structure of the educator's argument.

6.3.7. On Screen Elements with Video Windows

Many existing educational television programmes make use of on-screen text, either as a legend introducing a person or place, or for other labels and headings. Such use of on-screen text is likely to be different for video in multimedia. Most existing use of video in multimedia uses video windows. Text within such a window would be too small - especially considering the resolution of the video image. Font colouring and size for text on a television screen is very carefully chosen for legibility. Lines longer than thirty characters would normally be too small for the viewer to read on television. It is possible to overlay computerised text on top of the video window. The best solution would be to include text with a full screen image. If the video is in a window on the screen clearly, the text that accompanies it can be placed with the video window, and not included as part of the video. This gives rise to questions about the placement of the text so that it clearly relates to what is in the video image.

One of the considerations when using on screen text in video was the time allowed for the viewer to read it. Viewers encountering text that appears on-screen while the video is running must focus their attention on the text in order to read it before it disappears again. Trials of the Phase One software showed that this was also the case for multimedia if the text appeared next to the video window while the video was running. The extra control of video in multimedia must give more options in these circumstances. If the video sequence is short enough the same text could be displayed throughout the video, or if it was only appropriate to display a caption at a certain point during the sequence then maybe the video could pause - though this would be distracting.

The producer of multimedia should consider the effect of other elements on the computer screen while the video is playing in a window. If the rest of the computer screen has no relevance to the playing video window then the video need not be in a window at all, but can be full screen. However, Whalley (1993) suggests that full screen video may lead to passive viewing as can happen with linear video (see Chapter 2), whereas video in a window is located within the context of the learner's current work.

The idea of using the screen surrounding a video window to further enhance the interpretation and context of the video is interesting.

The screen space not occupied by the video window could contain extra information that relates to the video. This space could be used to fulfil such functions as positioning the video in the structure of the multimedia: a still picture used as the background could act as a continuing reference for the interpretation of the video; hypertext links relating to other sections of video or text could highlight at the appropriate points during the video; on screen buttons could offer control over the video playback and selected soundtrack.

If the other on-screen elements do not add to the video playing then maybe they would detract from or confuse the video's interpretation. Certainly it is worth asking in such a situation why the video is in a window at all and not full screen.

6.3.8. Size of Images in Video Windows

As we have seen from the discussion at the beginning of this chapter, the composition of an image is significant in the interpretation of that image. For instance, a long shot is used for establishing a scene and a big close-up (BCU) for emphasis. A BCU of an object signifies that the object has some significance in the narrative of the film. A BCU of a person is used to emphasise the person's emotions (Millerson, 1990).

Films that are destined for television and video are composed and shot differently than film shot for the large screens of cinema. There may be even greater considerations for the filming and conversion of video for use in the small video windows of multimedia. What were once the edges of the screen for video and film now become the edges of the video window within the screen.

Grammatical conventions for composition of the image dictate that the image is framed to draw attention to the important elements of that picture. Different areas of the frame have different pictorial value. The effect of the main subject changes depending on where it is in the frame. (Millerson, 1992). Similarly the placement of the video image on the computer screen affects the video's perceived importance.

During the conversion of the original video it was necessary to use video windows rather than a full screen video image. The head and shoulder shots of the presenter talking lost the authority that they had in the original video. The reason for this is partly the diminished role of the presenter (discussed earlier) and partly the effect of image size and position on the computer screen. The problem was increased even further when the shot was wider still to include the presenter talking while showing something else in the frame (see figure 6.2).



Figure 6.2 Size and location of a video window affect the authority of a shot.

An interesting possibility is the ability, with a little planning, to have the person in the video window refer to other on-screen elements, not only by talking about them but by looking and pointing too. In doing so, the implied narrative space of the video is moved from the studio into the multimedia program and so a better integration of the media is made.

The designer of educational multimedia will need to consider how the positioning and framing of the video window affect the interpretation of the video's content.

6.3.9. How does Video Sound Fit with the Video Windows

Sound from a multimedia video which is played in a window seems out of place. During construction of the multimedia programs it was clear that the sound accompanying the video did not function as well in a window as it did in the original full screen video. A full screen head and shoulders shot of a person on a normal television set would make their physical image size the size the viewer would expect, taking account of perspective, if they were sitting around three feet away. The voice is recorded to sound natural at this distance. A similar head and shoulders shot in a video window would position the viewer perceptually much further from the person. At this distance it would be harder for them to converse comfortably. The speech sounds less natural in this situation since they are at a distance but their voice sounds close. Davis (1969), when referring to the shot size within video says "remember that there is perspective in sound as well as vision. These should always be matched." (Davies, 1969, p57). Maybe the viewer has some expectation that this convention should also operate for video image size on screen. If this is the case then perhaps it is just a matter of the user of multimedia becoming used to the new conventions (grammar) of multimedia.

If the video is in a window the sound is not only accompanying the video image, as it would in television, but it is also accompanying the other on-screen elements. This was partly the problem with the background bird-song sound effects mentioned in Chapter 4. The background sound track was not only the soundtrack for the video but also the whole computer screen. In reality the viewer soon resolves this confusion and realises the nature of the sound.

The original video deliberately did not establish the location of the shot that included the bird-song sound effect. The bird-song acted as a clue for the later revelation that the pendulum was swinging above a child's roundabout in a park. In the original video this revelation followed on automatically, whereas in the multimedia this contradiction remained hanging until the learner decided to continue. As discussed in the concealed construction section above, care has to be taken with this type of technique.

This point also shows that background sounds (as well as visuals) which are part of a continuing sequence may need re-establishing if the sequence is segmented.

6.3.10. New Screen Formats

During the conversion of the original video, some sections were enlarged and then reframed so that the viewer could see some important detail that could be lost otherwise in a small video window. Care was taken during the reframing so that the new image was the same aspect ratio as the original. For multimedia this need not have been the case.

Just as screen size, position and image framing all have an impact on the possible interpretation of the video, a new possibility, *screen shape*, could alter the learner's perception as Millerson (1992) suggests:

A picture's shape can affect the viewer's feelings towards the scene. A *horizontal* format can give it stability, restfulness, extent... A *vertical* format can imply height, balance, hope... (Millerson, 1992)

The conversion from Academy screen ratio of 1.33, to the wide screen formats with ratios of 2.33 illustrates the type of changes that a switch in screen format can facilitate. When a classic two-shot was filmed with the Academy ratio, the screen size tended to focus attention on the speaker and listener. The wide screen formats mean that space either side or between the two characters in screen must be included too. This gives a change in emphasis. The conversation no longer looks so intimate, and also the more visible background calls attention to their relationship to the space surrounding them. Monaco (1978) suggests that this is neither better or worse, but it does mean that the way two shots were created and portrayed changed.

The makers of film have occasionally used different shaped masks to create a certain interpretation - such as the double circle mask used to indicate a point of view through

binoculars, or a single circle to 'spotlight' a certain action. Such conventions are seldom used now as they are considered to overstate the signified.

The motivation to use a different shaped window in multimedia could be that the shape of the window says something about the video - perhaps the window could be in the shape of a question mark, or the shape of a country. A different aspect ratio could be selected because the subject fits it better. Changes in shape of the window would work best if the reason for changing the shape was sufficient. Changing it just for effect, or 'because you can' may be all right in small amounts, but like the haphazard use of fonts in page layout, it may look confusing and ugly.

6.4. Development of a Multimedia Grammar

The grammar of multimedia has its origins in the grammar of its component media. Though it incorporates other media, the combination of media makes multimedia a new medium with unique characteristics.

The grammar of multimedia has to be more than just an extension of existing media grammars since multimedia differs from any other medium, not only by being a new combination of different media but by being interactive and learner controllable.

As we have seen above, the interactivity of multimedia means that the construction of the author's argument in multimedia will need to be quite different from conventional media. The user has control over the progression of the program, they can even be considered as authors of the particular narrative they 'create' through their activity. Existing ways of governing the revelation of the educator's argument using a narrative structure and presenters, do not utilise the user control that multimedia makes available.

The integration of the component media also makes for new grammatical possibilities for the multimedia creator. There are many possible ways to combine these media on-screen and user control adds an extra dimension to this. Issues regarding screen design, linking between sections and the inclusion of sound have been raised in the discussion in this chapter, but more study and experience will no doubt raise other grammatical areas that a designer of multimedia will need to address.

It is clear then that designers of educational multimedia will need to have an understanding of how the grammar works so that they can produce effective programs. In these early stages of multimedia they will need to look to how the grammar of multimedia will develop.

A grammar of a medium is not something that can be designed, though analysis shows how one might develop. The ability to recognise how meaning is created in a medium must be a prerequisite for any educational media designer. The grammar of multimedia is still in

development. The conventions that allow the producers of multimedia to cue and guide the learner in how to interpret the program have not evolved yet. Learners have to try to interpret this medium based on what they already know about existing similar media. During the development of multimedia, examining the existing media may help the educator design a system to exploit the users' ability to read existing media, and in time more complex grammatical constructions will evolve from this much simplified approach.

Examining how the existing grammars of the component media work and how their use in multimedia means that they must change must be a first step in the process of developing multimedia grammar. This chapter has started this from the perspective of video. Video and film seems a good starting point since it already combines moving pictures and sound and in a sense is already a multimedia medium.

The developments of new codes in the new medium of multimedia can be facilitated if existing codes of component media can still operate, or be adapted in their new environment. Metz (1974) describes how new grammatical elements form out of accepted stable narrative conventions during the continual evolution of filmic codes. Such changes can only happen through evolution where the viewers accept and understand the changes. Failure of the viewers to understand the significance of the changes would mean their rejection.

The originality of creative artists consists, here as elsewhere, in tricking the code, or at least *using* it ingeniously, rather than in attacking it directly or in violating it - and still less in ignoring it. (Metz, 1974, original emphasis)

Successful evolution of new grammatical codes in narrative comes then from the adaptation of existing conventions. Metz describes the relationship between film makers and viewers in the agreement of film grammar:

The speakers of ordinary language constitute a group of users; film-makers are a group of creators. On the other hand, movie *spectators* in turn constitute a group of users. That is why the semiotics of the cinema must frequently consider things from the point of view of the spectator rather than of the film-maker. (Metz, 1974, original emphasis)

The development of film grammar has been dictated by the film makers who are the creators of film and so of film language. They are able to speak as well as interpret the language of film. Avant garde films stretch the existing definitions of accepted film grammar that are later accepted into main stream film making. The success of the new codes, though, is determined by the viewers who have the ability to veto or accept the proposed changes by the film makers. This ability lies in the acceptance or rejection of the film by the audience that it was intended for. This is the limit of the input of the viewer into the creation of film language. As Metz observes:

To "speak" a language is to use it, but to "speak" cinematographic language is to a certain extent to invent it. (Metz, 1974)

The same would be true of the development of multimedia grammar if it were not for the possibility that users will have the ability to create and speak multimedia as well as read it.

For multimedia it is likely that at first program designers will try to apply the existing conventions of the component media. The thoughtful use of some of the existing grammar may be a good starting point. Designers need to be sensitive during the production of multimedia to what is possible or acceptable and to what does not work or is confusing - as this chapter does. They also need to be aware of how their program is received and used. This can be achieved both through developmental testing and evaluation. The feedback from this should allow the designers to adapt the conventions. As user experience and expectations mature so also will the grammar evolve.

This user led evolution is not enough though. It needs to work in conjunction with 'avant garde' production too, just as film makers do. Starting from existing grammatical conventions would not necessarily lead to the most effective development of the grammar in the unique properties of multimedia such as negotiated narratives and interaction. Designers must be prepared to experiment during the production of their programs. New designs must be properly motivated with the desire to usefully expand the grammar of multimedia and the user's reading ability.

For example, a designer may foresee the opportunity for a new type of interactive narrative that could be used to make a certain point in a program. The careful inclusion of this experimental grammatical form may or may not be successful, but will expand user's experience and could be adapted or used in some other form later.

New types of program design may be more demanding on the user but such demands may in the short term make the program more interesting (as in avant garde films) and in the long term expand the useful grammar of multimedia.

6.4.1. 'Overstated' Devices in Grammar Development

During the development of a grammar, overstated signifiers are useful. The viewer has to be directed quite clearly to the meaning of certain devices. As these devices become recognised as conventions, their use in the existing form is considered too overstated and so they evolve into subtler forms which themselves form part of a film style that may change over time.

Take for example the way in which film makers signify the passing of time. Original silent films often used a caption "the next day", even with the advent of sound captions were still used for crossing long time spans. Visual ways to show passing time evolved such as calendar pages being removed, or editing between the clock face showing one time to a later shot of it. Close up shots of candles burning down, or a newly filled ash tray are other examples. Even

this sort of device is considered clumsy now, a simple change of atmosphere, lighting, character location etc. over a cut is sufficient to signify an ellipsis of time.

New elements in multimedia may need 'over stating' at first so that a consensus for their interpretation can be developed. Such devices will mellow in time. Already we have seen this happen to some extent with computer graphical user interfaces (GUI). While a few years ago a button or gadget in a computerised environment needed an explicit explanation of its use, many users are now able to identify buttons and gadgets by their shape and position alone. Convention has reached such a stage that some gadgets on modern GUI's are barely visible. The window re-size operation of Xview versions prior to v.2, involved selecting a menu option to re-size a window. A window of textual instructions was on hand too in case of difficulties. Now the recent GUI of Xwindows 3.2 windows only look slightly different - they are raised slightly. Existing knowledge of conventions of GUI's enables the user to be able to find and use this gadget, and so this feature is no longer overstated.

Similar conventions were used in the multimedia stack in Phase Two. Buttons shaped as arrows allowed the user to advance or backtrack in the stack. An arrow pointing to the right signified the next page, and one to the left, the previous page. The functions of the buttons were not stated. The users of the stack had little problem identifying and using these buttons. All of the users had had some computer experience previously.

6.5. Conclusions

From the discussion in this chapter it has been shown that a grammar of multimedia does exist and that it has much room for development as use of multimedia increases. From this discussion and from the analysis of the video using Koumi's narrative framework, it is likely that such a grammar is going to be a complicated social construction, much like the grammar of film and video. Initial visions of multimedia that saw educational effectiveness as allowing the user to browse through a database of rich, non-linear databases, such as Ambron (1988) envisaged, were simplistic.

It is user control over the medium which makes multimedia so unlike other media. It is this difference that accounts for why the grammar of multimedia is unique and needs so much development. User control has diminished the authoritative roles of the presenters and authors and given more power to the user. Rather than telling or leading the learner, multimedia requires negotiation and collaboration between educator and student.

For an educator to help a learner move from a position of no knowledge of a topic to understanding, implies some sort of narrative or story in the transition. Traditional narratives rely on the educator leading the learner through a story. As the section on

authorship discussed, the grammar of multimedia will need to include methods of negotiating a narrative between the learner, program, and educator.

This chapter has looked at how a grammar operates in a medium like film, and has suggested where this may be similar to the grammar of multimedia. It has also examined some areas where the interpretation of typical film and video conventions would not apply for video used in multimedia in order to look towards ways of anticipating how multimedia grammar may develop.

Chapter 7 : Implications for Educational Design

7.1. Introduction

A problem with discussing how multimedia can be designed for effective use in education lies in the fact that there are many different types of multimedia and applications to education. Ideally this discussion should cover the design of multimedia in general so that it is of as much use to people as possible, although there is really no such thing as a general or even typical multimedia application. Readers may have their own idea of what constitutes a typical multimedia program, and apply what is said to that, but different perceptions of programs will result in different interpretations, which to some extent is good.

A general definition of the properties of a multimedia program can be found in the discussion in Chapter 2, which still leaves much scope (as it should) for many types of multimedia program. Some programs may be more didactic than others, some may limit the users to a very restricted area of knowledge, while others allow greater exploration or broader interpretations. Some programs may rely heavily on video, having a pre-defined narrative, or sequence, or still others give a greater freedom to the sequence. Different programs will have different quantities of tutorial sections or users' evaluation. Some may have sections with computerised simulations and intelligent tutoring, or may rely more heavily on browsing. The structure of different multimedia programs will be different, some having a pre-defined hierarchical menu structure, others may rely on links generated as the results of user actions. Figure 7.1 lists some of the key properties and the ways in which they can vary.

user control: free exploration / fixed sequence / default route

types of input: free responses/ option clicking/ variable changing / pointing

forms of feedback: extrinsic /intrinsic, general / detailed

structure: limited paths / limitation of domain / pre-defined narrative / user generated narratives.

formal style: narrative / non narrative

type of user: dedicated / casual / expert / beginner / special needs

approach: large database access / simulation elements / inclusion of ITS principles / links to real time data / links to real people via conferencing.

Fig 7.1 Some of the variables in the definition of multimedia

As a program may have all or any combination of these properties, this means that there is a great number of types of multimedia program that are all covered by the term multimedia. Consequently, in the discussion of general multimedia design principles, some principles will apply to some types of multimedia more than others. Using various programs this thesis investigates the properties of level of user control, narrative form, structure and types of feedback in an educational program. Findings are therefore generalisable to programs of this type, but not necessarily beyond that.

This chapter will summarise the findings of the research carried out for this study in terms of their implications for educational multimedia, for multimedia design in general, and for further research in this field.

7.2. Implications for Instructional Design

The design of educational programs using the new medium of multimedia will not only require rethinking because of media production oriented issues, but also because of the pedagogically significant differences between this and other media. This section summarises the key findings on instructional design for multimedia.

7.2.1. Simplify the structure

Students in Phase 1 did not recognise the main point taught in the program, whereas students in Phase 2 did. Students who used the linear version Phase 1 found that they did not know where the program was going and how the points linked together. The viewers of the video version did not have to be concerned with the progression of the program in the same way since they were not in control of it - you trust the narrative of a video to take you through its argument.

The structured multimedia version made the program structure clearer by separating out the main parts into a menu. Students who worked with this version still did not identify the main point. The program structure was clearer but the structure of the argument was not. Students were still unsure how the individual sections related to form the main point. The sections were a set of examples that illustrated the main point. Time within the sections was spent discussing the examples, but there was little time spent relating the example to the main point and students came away having made their own minds up about what was common between the examples. This finding is similar to the relationship that Laurillard (1991) found between identification of the main point and the structure of video, which is discussed in Chapter Two.

In Phase 2, the program and the argument structure were clear, and students recognised the main point.

It is not enough to make the structure of the program clear if this does not reflect the structure of the program's argument. A clearly defined argument structure will help students relate program structure and argument points to the overall argument.

7.2.2. Clear structure aids navigation

It was hoped that the spoken element of the Phase 1 structured program would help students navigate by clearly labelling links between sections so that the learners understood the relationship between cards and also the relationship between argument points. Some users said that they found this voice useful in navigation, though none of the learners in any of the multimedia programs had any trouble navigating the multimedia programs. There are three likely explanations for learners not having any difficulty navigating:

The structure of the programs in the Phase 1 was based around a linear narrative.

The programs (especially the second Phase) were simply structured and fairly small.

The programs were more didactic, sign-posting the suggested student routes through the material.

Few students deviated from the logical routes through the material. Either students did not find the need to access the information out of sequence, or they were not motivated to. Phase 1 interviews showed that many students had not understood the program, and that the post-test was motivation for some students to want to go back into the program and look up details that they had not understood. In Phase 2 the last task provided motivation for some students to re-examine the first task.

Lack of user motivation is a likely explanation for why learners did not review material that they had not understood.

7.2.3. Address misconceptions directly

Phase 1 of the study showed that students shared misconceptions about the phases of the moon. Many students still held these common misconceptions after they had completed the program. Phase 2 specifically addressed these misconceptions and was successful in significantly reducing the number of students who adhered to them in the post-test.

This success was due to simply directly addressing the identified misconceptions. This demonstrates the real benefit of trialling the courseware with the intended users.

7.2.4. Provide intrinsic feedback

As expected from Chapter Two and Clarke (1985), there was no benefit for learning gain from simply transferring the original video to multimedia in Phase 1. Similarly there was no increase in learning from providing navigational tools and greater learner control over the material.

The increase in learning gain from Phase 2 was not due just to transferring the existing programme to multimedia but due to designing specifically to take advantage of the interactive capabilities of multimedia (as discussed later in the 'Interactivity' section).

7.2.5. Negotiate the narrative line

If the students have more control over their learning then they must know more about the available resources as they plan a course for their learning. A traditional narrative would not offer enough detail for this to happen. On the other hand, simply laying out the resources and setting the student the goal of analysing them to gain a particular understanding is also not feasible. This would require the students to have great learning skills, to be able to find their way through an unfamiliar subject domain and be able to see the perspectives of the author/expert without any guidance from the expert / teacher.

For unsupervised student use of an educational multimedia package the role of recipient of a narrative is inappropriate since it does not allow user freedom, and the role of free explorer is inappropriate since there is no narrative or expert guidance through the material. So, how should multimedia be designed ?

As discussed in the last chapter, a narrative is a linear structure. With this in mind, Plowman (1993) considers the possibility of designing interactive video programs so that there are certain, known, linear routes through the program. In this case it is possible to check each route's narrative to see if it is coherent. She also suggests that there is a need to see how interactivity can be developed within a linear structure. While this type of planning may be suitable for some multimedia programs, a choice of one of a few known narrative lines is perhaps at the cost of greater user freedom. As 'TerminalRISK' shows in Chapter 3, it is possible to use a conventional narrative in multimedia by making a balance between narrative and user freedom. A compromise such as this may provide a way of bridging the gap between existing narrative media and an advanced multimedia program that supports its own flexible ways of including narrative.

The human ability to recognise and follow narrative must not be underestimated.

Nash (1990) refers to narrative as 'getting coherence'. Our ability to do this is practised everyday as we use similar skills to follow and make sense of the world going on around us.

As Eisenstein (1949) observed, viewers will even attempt, and succeed in, attributing a narrative to an apparently unrelated series of scenes. Perhaps when the grammar of multimedia has matured more fully there will be less restrictive ways of including narrative.

With this in mind Plowman (1993) suggests that the users construct a narrative as they read and that users in getting coherence from a text have defined their own narrative. The designer of the multimedia program has supplied the components of the narrative and has set the parameters that the learner works within. This environment that the educator provides can guide the learner towards certain conclusions, the exact narrative path that the learners take being the one that is most suitable for them.

Laurillard (1994) describes this interaction with the computer as 'guided discovery learning' where the computer is not a narrator / story teller, but a collaborator in learning.

The basic design principle must be to think in terms of what the learner must do for their part, and how the 'teacher' (i.e. the multimedia program) should support them in that.

(Laurillard, 1994 : 6)

Narrative need not always be a static construction of the author. Instead it can be seen as a collaboratively established route through the program that forms a coherent argument for the student.

7.2.6. Provide motivational devices

Phase 2 managed to engage the learners by making the program interactive and by using a scoring mechanism. The program did fulfil its aims in that students were able to predict where on the moon's orbit certain phases would be seen from earth. The program was not entirely successful however since the learners found and used surface level strategies to complete the tasks and post-test.

Consideration must be given to possible ways to encourage the students to think in depth about the subject of the program. The learners worked a trial and error strategy until they could discover a system, or set of rules, by which they could successfully complete the task. This problem-solving activity, while being an improvement on the lack of engagement of the first phase, was still incorrectly focused.

Even though students were better engaged, their engagement was not useful in learning. Norman (1993) suggests how this may have happened when he warns us that engaging students by entertaining them does not encourage reflection. He considers two types of cognitive processes, experiential and reflective.

The experiential mode is when we perceive and react to the events around us, efficiently and effortlessly - this is the expert mode where already learned skills and knowledge are exercised. The expert does not need to reflect on routine actions and decisions.

The reflective mode is that of "comparison and contrast, of thought, of decision making. This is the mode that leads to new ideas, novel responses." (Norman 1993:16)

Reflective cognition requires more laborious effort, rather than the enjoyable reflexive experiential learning.

Reading the constructed narrative of video is normally an experiential process. Skilled readers can make instant interpretations of the text, little reflective thought is necessary to understand it.

in most simple reading, we must make these kinds of inferences to understand the meaning, yet we do not continually stop and ponder each sentence as we read it, certainly not with everyday, non technical material. (Norman 1993:23)

The same is also true of television narratives, perhaps more so as discussed in Chapter Two, since television provides richer information than print so the reader is less active in imagining the scene.

Interaction requires user actions such as decision making and responses to questions, but, as we saw in Phase 2, this need not require reflection. The learners were engaged in a reaction to the feedback of the program rather than a reflective response.

Entertainment operates in the experiential mode, it may provide new experiences, but not necessarily new ideas or concepts. Experiential learning is not enough, but it is a good motivator. If a student is to learn from multimedia it must be more than just motivating.

If a program itself is to be educational, then enthusiasm generated must be capitalised by the program. A multimedia program that just generates interest in a topic will only be of educational use if followed up by more reflective learning. Multimedia can be used in this way as video already has, but properly designed multimedia is capable of much more.

Successful educational multimedia needs to balance experiential and reflective modes of learning. The generation and direction of student motivation can be used to help the learner achieve the goals of the program and to expend the effort in more demanding mental activity. The production of this enthusiasm can be understood and controlled from knowledge of how the grammar of the medium works.

7.2.7. Negotiate learners' goals

While the Phase 2 program was more successful for the reasons given above, it remained an imperfect teaching program for one important reason: the students set their learning goal to completing the program. This can be paralleled with Laurillard's (1984) findings on students' perception of goals. Analysis of students' reports on their approach to a task revealed that their perception of a task set by the teacher was not centred on the task itself, but was instead centred on satisfying the teacher's requirements. The same can be seen for the goals set by Phase 2. The learning goal set by the program, and originally by the educator who designed the program, was that of understanding *why* the phases of the moon change. Instead though, students were able to satisfy the goals of the program not by understanding *why* the phases change but simply by remembering the sequence of the phases.

In a tutorial situation, the teacher would have spotted the conflict in interest and would have attempted to adjust the goals of the student accordingly. The program was not designed to expect this particular strategy and so could not adapt.

In Task One of Phase 2, the task could loop for ever asking questions, but students only answered as many questions as they felt they wanted to at the time. It did not matter if they answered these questions correctly or incorrectly - or at all. There was no teacher to satisfy in that task, only the ultimate goal of the program to work towards, requiring a certain amount of motivation to interpret the task in terms of that goal. Task Two was different in that it required the users to satisfy a certain criterion (a score of five). Now the students did have a goal - that of satisfying the teacher / computer goal of five points, not of understanding the moon phases. Had the actual goal of the students been to learn about the phases of the moon the scoring in Task Two might have been annoying rather than motivating since it sets up a secondary and irrelevant goal.

If the educator's goal can be established as the actual goal of the learners, then design of educational multimedia would simply be the task of facilitating learning by providing the proper guidance and support to the students. But since such good motivation cannot always be counted on other false goals could be employed to encourage students to work (e.g. get a score of five, catch the crook, get the rocket to the moon). In this situation the fulfilment of the false goal must lie at the other side of a set of tasks that students must complete in order to get there, the tasks each requiring the student to work with some aspect of the educators real goal. It seems inevitable that reflection, while completing such tasks, would revolve around strategies to complete the tasks easily and quickly so that they might obtain the false goal, consideration of the educator's real goal only extending as far as necessary to complete the set task.

Such a depressing scenario would apply for programs that underestimate the learner to the extent of assuming they have no motivation for the educator's goal, and then patronise them with more gratifying goals. The truth for many students is that they do have some motivation to learn, and that it must be encouraged and their progress rewarded. Their path to the educator's goal should be made interesting with interactive tasks that reveal something new that aids them in discovery.

For a multimedia program to be effective, the learners must not only be able to identify the goals of the educator / program designer, but must also encourage the learner to work towards these goals, rather than just satisfying the requirements of the program. If multimedia can provide sufficient flexibility and user control so that learners feel some ownership of the learning and of the goals, then maybe they can work towards developing learning strategies for achieving these goals rather than developing strategies that just meet the requirements of the program / educator.

7.2.8. User attitudes

The students who used the multimedia programs had no difficulty understanding how the programs operate. This is perhaps due to an effort in the design of these programs to ensure that they followed existing guidelines on usability. This design effort was due to the observations of how quickly even dedicated students became frustrated with some aspects of the interface of the TerminalRISK in the preliminary study. Once the user had become frustrated with the control of the program then the program was not as rewarding to use and the learner lost enthusiasm and patience for working with the program.

The simpler nature of the multimedia programs in Phases 1 and 2, and the effort to follow design guidelines resulted in learners having no difficulty with the control of the programs. This did not mean that the users worked happily with the programs, instead the pedagogical design of the program in Phase 1 let the students down. In Phase 1, programs did not act to motivate or engage the students. The inclusion of video was not enough to motivate the students. Nor did following the narrative of the original video help in motivation.

The narrative in the original video used video's grammatical techniques to texture the narrative and hook and maintain the attention of the viewer. This helped to carry the students through the videotaped version, but even though the multimedia versions contained much the same video and narrative structure, these elements did not operate and their benefit was lost.

Although there was a lack of motivation to get involved with the programs in Phase 1, the learners did appreciate learning in this way. Many of them recognised the fact that this type of multimedia allowed them to progress at their own pace, giving them time to think.

All but one student who saw the video and worked with the multimedia version rated the multimedia version as better.

Novelty value may have played its part in the student enthusiasm for multimedia, but students were not prepared to work any harder simply because they were working with the computer. As the preliminary study revealed, the fact that a computer was involved meant that some learners expected to put less effort in and still learn as much - as if somehow the computer had automated the learning process.

This attitude meant that students did only the amount of work necessary to complete the tasks and no more. If there is an easier method of completing the task than the one the educator wanted, then many will take this instead. If student activities using multimedia replace previous teacher organised activities, then extra effort must be used during the design to ensure that students cannot short circuit the program in this manner.

User freedom and control was not reason enough for the students to learn more effectively either. Although students appreciated the extra control, this alone did not mean that they would apply themselves any better to the task.

What was necessary to enable student learning was greater engagement, this being achieved through the pedagogical design of the program. In the Phase 2 study this was accomplished by clearly stating the goals in the program, by using greater interactivity and by paying attention to the pedagogical design of the program.

As we saw from the Phase 1 study, the mere inclusion of multimedia, video or user control is not enough to motivate students to learn. What is needed is a proper understanding of the grammar of multimedia so that proper use is made of interaction, feedback and user control, and to support the pedagogical structure of learning such as clear goals and a coherent line of argument.

7.3. Implications for Multimedia Design

The three related areas that we have found to distinguish multimedia from other media are the interplay of different media, the role of narrative and the use of interactivity. All these affect what might be called the 'grammar' of multimedia, which itself has clear implications for design.

7.3.1. Media Selection Within Multimedia

Multimedia offers the ability for different media elements to be used for different parts of the course material. In media such as video or print, the program designer just needs to

consider how best to construct their argument. For the designers of multimedia, a further consideration is necessary - "when is it appropriate to use which component media?".

Audio

The use of a spoken precis of each card as it was shown, had the detrimental effect that students felt that they did not need to read the main text on the card. It did appear to have some benefits, however that could warrant some more examination. There is some evidence that spoken precis of the cards:

- aided navigation because each spoken link built up to an audible narration of the user's route through the material. If users browse quickly through the material they are given a constant commentary of the progression and relationship between the cards.
- reinforced the relationship between cards. The user still having the previous card's point in their mind, is presented with a spoken precis of the new card, and so the relationship between the cards is highlighted.
- caught the student's attention. The key point of the current card is explained clearly in such a way that the student cannot fail to hear it. While students still have the ability to control their own learning, the spoken precis could be used to make the argument of the educator clearer. It could perhaps fulfil some of the functions that the presenter would have in an educational video; sign posting and guiding students' expectations and interpretations.

The negative effect of the spoken precis needs more investigation too. Having received a verbal summary of the contents of a card, some students did not feel the need to read the main text of the card, instead they thought that they had sufficiently understood the card from listening to the precis and examining any stills and video on the card.

Maybe this problem could be overcome if the spoken content of each card was extended to include enough information so that the student could follow the course material sufficiently from this and from the visual elements on the card. In this set-up the text on each card could either match the voice, contain further information, describe an alternative perspective or summarise the voice. The effect of these different set-ups needs more research.

It was noticed during the observations that some students responded verbally to a spoken link that posed a question. Perhaps the spoken link could be used in this way to motivate users, posing rhetorical questions or setting short-term tasks or aims. The spoken nature of this type of link may be more effective for this than if it was textual.

There is clearly benefit to audio links of this type, their use warrants further research in order to establish how they can best be used.

Text

Both with the version with spoken links, and with the versions without, students did not want to read a large amount of on-screen text, and avoided doing so when possible. If an apparently easier way was available for the students to understand the program's message then they would take this instead. All the students looked at all the video sequences and stills at least once, many a few times. Students in Phase 1 reported that they read the text that was directly linked to the video or still (the link between a video sequence or stills and the text that accompanied it was established by locating the text directly underneath the visual element). The main body of text on each page, which was not associated directly with a visual element in this way and consisted only of a few short paragraphs, was often read quickly, not completely or not at all. When the spoken voice was available students were even less likely to read the main text.

Not reading on-screen text was due to a lack of student motivation, resulting from lack of interaction, clear aims, and feedback on progress. The Phase 2 program addressed these problems, and also associated the main text (where there was one) with a visual element. In Phase 2 there was no sign of users not reading blocks of on-screen text, though Phase 2 used much shorter text-lengths, a maximum of 100 words.

Users of TerminalRISK in the preliminary study also stated that they did not like reading large amounts of text from the computer screen. These users were better motivated, and read the text presented to them on-screen, but admitted that they did not like the amount of on-screen text. Educational multimedia designers need to be aware of this problem, and find ways to aid reading large amounts of on-screen text, or ways to break up the text or present the information in another form.

In summary, long passages of text on-screen are not read by poorly motivated students, and are not appreciated by other users. Learners are more inclined to read text if they have clearer aims, motivation, or if it relates to some activity or visual element.

Video

The Phase 2 multimedia program made much less use of video than Phase 1 programs. This was partly because Phase 1 was trying to uncover some of the issues arising from the change in media while maintaining some of the original attributes of the original video. Phase 2 was derived from the findings of the first Phase and so did not need to be so reliant on the original video. The Phase 2 material did not cover as much of the subject area as Phase 1 so some of the video from Phase 1 was not relevant.

The video that was included in Phase 2 was added since it was particularly effective in the first. Students were observed responding positively to that sequence in Phase 1 and some referred to it in interview later. The sequence shows a man lifting the moon out of the earth's shadow and so demonstrating graphically the inclined orbit of the moon that explains why we observe a full moon and not an eclipse.

Much of the rest of the original video about the phases of the moon showed the model that had been built in the studio. While it was necessary for the original video to use this model to explain the phases, it was much better in the multimedia version to build an interactive computerised model which the students could manipulate themselves.

This does show that video that was necessary for the original video, and may have been effective in the original video, is not necessarily good to use in a multimedia course. On the other hand, some video, which may show something particularly visual (like the man lifting the moon from the earth's shadow) is as at least as effective in multimedia.

Single media courseware has to deliver its entire argument through that one medium. During the design of multimedia courseware the educator must decide which of the component media best suits each part of the material. In the above example, interactive computerised models are better than video ones, but the makers of the original video could only include video models since that is all the medium could support.

Identifying which medium is to be used when and for what in multimedia is not a simple issue. Each media has different strengths and roles. How the media interact and can be used together is still being discovered. To construct multimedia courseware requires that experts, with different experience and skills appreciate each other's expertise in order for the most effective solution to be agreed. Such design teams should have a very clear vision of the product they wish to construct so that the correct balance and integration of media is achieved.

The example of the moon phases not only demonstrates the need to select the right media at the right time, but also demonstrates the benefits of trialling the multimedia program with real users to see what they respond to and how.

From the study carried out here, the main conclusions we can come to about the role of video in multimedia are:

That video is a rich medium that can be included in a program, its strengths still being those discussed in Chapter Two.

That the appropriate selection of when to use video comes from understanding its comparative strengths, negotiating with other media experts, and trialling the program with its intended users.

That, in some instances, the role it plays in TV may be played more effectively by interactive graphics in the multimedia context.

7.3.2. Narrative

A narrative medium has specific rules for its internal structure that are sometimes referred to as a grammar.

As discussed in Chapter 6, a narrative is essentially story-telling. The teacher has a story to tell and will use their expertise and knowledge of the story to bring all the appropriate points in at the right time and knit them together in a way that the reader can follow. Educational television does this, and Koumi's educational television screen-writing framework, Chapters 2 and 4, shows how video producers may construct their story. It shows how the storyteller can hook the audience's interest by hinting at later revelations, and how the storyteller may tell the audience what the story is about - but only reveal each step of the story when they need to. The construction of a narrative is complex as the analysis of the video section in Chapter 4 demonstrates.

As discussed in Chapter 2, a multimedia program that encompasses intelligent tutoring principles may be able to adapt its narrative in response to students' performance - perhaps identifying certain misconceptions.

If the user is given even more control of the program, then inevitably the role of storyteller becomes less defined as the users generate their own paths, either working towards goals defined by the system or defined by themselves. In video or print narratives only the final aim of the program is revealed. The route through the program is revealed as the narrative progresses. A multimedia program offers the ability for student control of the path through the material. In such a case there is no narrative in the multimedia program.

In the preliminary study (chapter 3) the program TerminalRISK used a fictional narrative in teaching auditors how to identify risks in computerised information systems (CIS). While allowing a certain amount of user freedom the program was still intrinsically didactic, and while in theory the users could work through the program in any sequence, they were guided by the design of the program to work through in a pre-defined sequence. This defined sequence allowed the fictional narrative that ran throughout the program to be followed by the learners.

The narrative and program design created a default or suggested route. The learner can choose either to follow the route and sacrifice control over interaction, or not follow it and flounder. As seen from the empirical studies, where a route is provided learners will take this and not take responsibility for their own learning.

The fictional narrative about the missing CIS auditor was only part of the whole program's narrative structure. The program's overall narrative structure, that is the entire educational argument of the program, took the students through a five stage approach to identifying CIS risks. The overall narrative utilised the fictional narrative as a device for a number of reasons.

User attitudes to it were positive, and identified it as a source of order and motivation. Thus from the empirical study it seems that the fictional narrative served a number of useful purposes:

- helped order the individual argument points in a way that was easy to follow and understand. This extra clarity in sequencing may help the presentation and understanding of the more complex concepts underneath.
- provided motivation. Students working so that they can see the conclusion of the fictional narrative.
- provided a fictional 'what if' scenario where examples showed what might happen in a real situation. This linking to types of situations that could arise in the 'real world' also motivated the learners.
- provided a change in mood / gravity of the overall program narrative that helped to texture the learning (Koumi, 1991) and assist the concentration of the learner. This change in mood allowed time for, and encouraged, reflection and consolidation.
- helped the learner to remember the sequence and detail of the overall narrative / argument of the program. If fictional events link to more complex argument points, the memory of the fictional event in the sequence of the narrative may aid recall of the argument point, and how that point relates to other argument points.

From her study, Plowman (1993) affirms points one and five above when she concludes that narrative in conventional media provides coherence and continuity.

It is clear that the possible inclusion of narrative forms in multimedia is desirable, but a number of key properties of multimedia that differentiated it from other narrative media resist the conventional linear narrative (in summary from previous chapters):

Time and pacing is under user control. Though few narratives on video are in real time, their pacing is carefully controlled. On-screen time lengthening and shortening, narrative time and pacing is completely under user control in multimedia. The example, from Chapter Four, of the presenter placing the pencil to be knocked over 15 minutes later by the pendulum, is an example of real time in a video narrative that does not work for multimedia.

User control means that the user can decide what route to take through the program. This presents difficulties in producing a linear narrative.

Interaction and adaptivity require that the program responds to the users' actions. No conventional narratives change with the users' actions.

The non-continuous nature of multimedia, where users stop, start, make detours and proceed at their own pace, is very different from the way that a viewer sees a film or video narrative. This fragmentation would interrupt the flow of such a narrative.

The evident construction of a multimedia program, as contrasted with the carefully hidden construction techniques of a television narrative, may mean that the illusion of reality that users like to enter into while watching a film/television narrative is spoilt.

Designers of multimedia programs will need to find ways of dealing with these points if they want to take advantage of narrative.

It is clear that narrative does have a role in multimedia, but because multimedia is a unique medium its narratives will have to be different from existing narratives (as seen in the section 'negotiate the narrative line' earlier).

7.3.3. Interactivity

If interactivity is defined as in Chapter Two, then multimedia has the ability to be an interactive medium. That is the user's actions change something in the system that determines the feedback.

Whether a particular multimedia program is interactive or not depends on its design. The multimedia programs in Phase 1 and, of course, the video, were not interactive. The programs allowed the user to work at their own pace and to an extent browse the material, but then so do books.

Analysis of Phase 1 showed that the students' engagement with the programs was low. Lack of interaction with the program can partly account for the lack of engagement. Students were only able to move from card to card, reading (or not reading) the passage of text on each card and looking at the video sequences. The potentially motivating presence of the video that could hook and maintain some pace and rhythm was lost as students had control over the programs. Students needed some form of motivation, the learning goals not being enough. Some interaction was needed where the learners' actions would change the feedback, where what they did in the program made some difference to the outcome. This interaction was

lacking in Phase 1. Had the students worked through the programs with their eyes shut it would have made little difference to the way the program progressed.

Having identified this as a problem, Phase 2 consisted of two interactive tasks, the second of which would not allow the students to complete the program until they had demonstrated that they had a strategy for completing the task. Consequently students on the second task were much more active and engaged in the material.

This demonstrates the value of exploiting interactivity to the fullest extent of allowing both control, and feedback on users' actions. The success of this interactivity illustrates the need to modify the traditional narrative to something more negotiated.

7.3.4. Development of Multimedia Grammar

Both the preliminary study and the Phase 1 and 2 studies provided supported the notion of a need for some kind of grammar of multimedia. Chapter 6 discussed some of the elements of such a grammar.

The grammar of a medium is the basis by which the raw ingredients of that medium are brought together and connected with the common conventions and interpretations of the readers, so creating a meaning or argument in the medium. This being the case it is important that educators and multimedia developers know how to use this grammar in their work, and be aware of how this grammar works and will evolve.

This thesis has discussed a number of areas that make multimedia a unique medium: it is these differences that will determine the evolution of multimedia. A summary of the differences between the grammar of multimedia and the grammars of other media shows that most of the differences originate from user control, interactivity and the mix of media type.

The user has greater control over the multimedia program than they would over a video or film since they can control both the pace and sequence, or over a book since the multimedia can be interactive and adaptive. This control changes the role of author, the author having to provide enough information so that the learner can devise their own learning strategy. The author can no longer prepare a single narrative line that the users must follow, but must provide the users with enough information so that they have control over their route. The author must also provide cues, hints, progress information and guidance for learners when necessary so that they do not get lost in unfamiliar knowledge. They must also provide interactive tasks, short and long term goals, positive feedback and motivational devices so that the learners know where their destination is and have some reward and encouragement to get them there.

The mix of different media requires that the designers of multimedia consider how to create a program that makes use of the appropriate medium or type of user activity at the appropriate time. Designers need to consider how to link argument points between different media and across different types of user activity, the narrative being negotiated between the author and learner rather than simply a 'story' that the author tells.

The integration of different media and user control requires new considerations in interface design and screen design; the presentation of on-screen text (length and positioning), video windows (size, shape and content), sound (level and attachment to on screen elements), program structure (explicit, types of links and browsing).

These attributes of multimedia that this thesis has explored make multimedia a new and unique medium. How might this new medium evolve in the future?

The grammar of multimedia has much in common with the grammar of film and video, as it combines different modes of representation and is both complex and subtle. The readers of such a grammar are able to derive meaning from the media, but are often unaware of the processes by which this interpretation was created. The designers of these systems, on the other hand, must learn to recognise how the medium works in order to use it to their advantage, just as film-makers know how to manipulate sets, actors, editing, sound, lighting etc. to create different interpretations of the images on the screen and finally the complete narrative or argument of the film.

Since the grammar of a medium is composed of conventions between program maker and reader, it must evolve over time. An awareness of this process should allow for a selective evolution of this grammar.

Educators can help in the useful development of the media by selecting elements that are most effective and by using these in their programs. To determine which elements work better than others will require experiment, and listening and watching users.

It is likely that there will be different genres of multimedia program, each with slightly different conventions and user expectations. It is possible to interpret the different varieties of computer program that we already see in this way. For example amongst computer games we can identify god games, graphical adventures, platform games, simulations, arcade games. The player recognises the type of game and already has a set of expectations and understanding of what the game does and how it will operate. New games maintain interest by adapting the formulae with new features or by borrowing elements from other games.

It will not be just the designers of educational multimedia that will determine the evolution of a grammar for multimedia. The borrowing of conventions from other genres of multimedia and users' experiences of other multimedia will produce a general evolution of multimedia

with only slight differences between genres. Entertainment, reference and training multimedia are likely to play their part.

A further factor during the development of multimedia is the users' production of multimedia. Rather than users accepting or rejecting conventions that multimedia developers offer to them, increasingly powerful home computers offer the users the ability to create their own programs.

Multimedia is a new medium that will certainly be used in education by educators and students to prepare course material, and as it is accepted in schools and as entertainment at home, users will inevitably start to produce their own material, as many home video makers have done.

As the production of multimedia is taken up by home and educational users we may see a proliferation of public domain material. Such material may mimic the grammatical conventions of (by then) established multimedia production companies, but also may adopt their own conventions and styles that in turn the larger companies will adopt. The same sort of thing already happens in the music industry as talent scouts search for the next new sound amongst the underground music scene.

The possibilities of users having control of a system where they can create and integrate animations, music, pictures, text and video and then distribute their creations to other users to use and adapt on their systems have not been realised yet. Whether home users will want, or be able, to produce and modify their own multimedia programs, remains to be seen, perhaps they will just be users of ready made material. The means to produce video at home has been available for some time now, 'camcorders' have sold well, but there has been little evidence of any quality home videos. This is perhaps because the equipment to properly edit material is expensive, video is not easily duplicated and shared with other users, and because the makers of home video do not know how to construct a television narrative. Computer digitised video can help solve the first of these two problems, but media literacy is more difficult to establish.

Many years are spent at school teaching children how to write a coherent sentence in a language that they can already speak. A student may understand a film perfectly, but most will not be aware of how the language of film operates and so not know how to construct a film that adequately expresses their point of view. Is the same true for multimedia?

Certainly given the correct tools, a student can produce a multimedia document that expresses a simple argument so that others can understand it. The problems may arise if they were expected to produce anything more complicated - either something with a complicated structure, that was cognitively difficult to grasp, or that showed a particular interpretation or perspective on an issue. Assignments that required such treatments would normally be for

older students who have had existing experience in producing simpler documents. Just as younger students are only expected to produce simply written short stories, younger producers of multimedia would of course produce simply constructed multimedia, and with practice, experience and tuition work up to more expressive work. If film making was part of the curriculum from an early age and had proper tuition we would have a nation of film writers as well as readers. As with written language there are some people with a particular talent that become great authors and script writers, while others are happy to remain readers who are able to write letters and notes.

However it goes, whether multimedia becomes a medium like reading and writing, open to all, or like video, where most of us are customers of the experts' production, those who produce it will be exploring the new grammar and will do this more effectively the more they understand how it works.

7.3.5. Methodology

The empirical work centred on trying to determine the learners' activities. Uninterrupted observation of the learners revealed their approaches to the program and to learning. Observations were followed up with an interview that asked them to explain what they had done, questions being based on their particular approach, or on any problems they had encountered. The times when the learners had problems were often the most revealing - since their expectations are more easily seen when they are not met.

Qualitative data was collected from a number of different sources: observations, interviews, program logging, and from discussion in the pre and post-tests. The analysis of this data was successful in determining the learner's approach and relationship to the program. By focusing on the users it became easier to attribute differences in learner performance to specific elements of the program design, rather than a more simple comparison of learning gains that would only show how successful the program was in a particular instance.

Quantitative data from scoring the pre and post-tests and from the computerised timings of student progress through the programs added further weight to the findings.

The design of the materials can be a revealing process in itself. The conversion of video programme to multimedia was particularly useful. As the results in Chapter Four show, many of the differences were revealed during this process. The process forces the person performing the conversion to examine the way the media and the narrative works and is structured. Some experience in video production perhaps allowed me to recognise some of the issues that were uncovered, but since we are all experienced readers of video narrative I suspect that other people would come across similar discoveries during this type of concession, if not always being able to identify their nature.

The use of Koumi's (1991) framework in Chapters Two and Four also proved to be a useful tool to use in identifying how video works and recognising its structure. The framework would be particularly useful for researchers who are less familiar with video production.

The use of diagrams during the post test and interview was a good way to get the students talking since they have to draw something. The diagrams helped the students explain concepts that they could not put into words properly. However, it was very difficult to match their diagrams to the transcript of the audio record of the interview. A video of this would have been more useful during data analysis.

7.3.6. Guide-lines for multimedia production

While much of this thesis has concentrated on raising and discussing issues rather than finding answers it is still possible to draw up some general production guide-lines that come from the research in this thesis. These guide-lines should be viewed as flexible just as many of the guide-lines that you can find in books about film and television are.

Keep the program structure simple and make sure that it relates to the structure of the programs educational argument.

Making available options clear will aid the student in making decisions about navigating the program.

Provide intrinsic feedback on user's actions so that they can clearly see the consequences of them.

Encourage reflection by providing extrinsic feedback on the actions of learners.

Where possible support learners in the way that they want to work.

Linking on-screen text with graphics, tasks or video will encourage students to read it.

Provide motivational devices - make the program interesting and fun to work with, though be careful that these devices do not get in the way of students who do not want them.

Designing the program to directly address students' misconceptions will help dispel them.

Make sure that all aspects of the program's design is motivated by the need to make the program more effective for the student.

7.3.7. Further Work

This thesis has raised many questions about the design of multimedia in education and the development of a grammar of multimedia. All of these questions may offer scope for more research. The observations that arose from the construction of the multimedia programs in section 4.3 could all be taken as starting points for more specific research into these phenomena. For example a project could look at the role of spoken links in navigating a multimedia program, or the effect of the position and size of a video window on the perceived importance of its contents.

The area I would particularly like to see followed up is notion of negotiated narratives and the relationship between narrative and interaction. Narrative in a medium clearly has the benefits of making the program more coherent and motivating the learner - whether these can be maintained while adding the benefits of user control and interactive tasks remains to be seen. An investigation into this must look at how much narrative structure the educator should build into a system, and to what extent should the learner be able to follow their own route through the material - can the program be made to adapt its guidance to support the student in the way that they wish to work? It would also involve looking at the role of presenter and how to add voice to the guidance that the learner needs. A study in this area would have to look at the structuring of multimedia programs and how the learning objectives should be defined.

An empirical study that focuses on students' use and expectations of using multimedia with different types or levels of narrative guidance might be a way in which to follow up these issues.

7.4. Conclusions

So far multimedia has failed to provide guidance and goals while still supporting learner freedom. Narrative can provide direction, goals and coherence, but fragmentation and learner control in multimedia inhibits the use of existing narratives. The discourse possible between computer and user means that multimedia can support a new form of narrative - a negotiated narrative. To construct such a narrative the program designers need to understand how the new grammar of multimedia works - and how to use it.

I suspect the questions that this thesis raises are ones that many people who develop multimedia have been asking in some form or other as they try to create programs in this new medium. What this thesis contributes is to give a more solid form to what have been vague questions and feelings of need that multimedia developers have had. In setting down these issues I hope that they may become a firmer starting point for further discussion and research.

More specifically this thesis raises and discusses questions about narrative, interactivity and grammar, and in doing so points to a new approach to multimedia design. This thesis also contributes to the knowledge about the educational design of multimedia in its discussion of the role of structure and the need for clearly defined goals. By looking at multimedia this way, from the perspective of the user's relation to multimedia, and not from a technological perspective, it may be possible to tap the full potential of this rich new medium.

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Appendix A: *Terminal*RISK Questionnaire

Learning Assessment Questionnaire

NAME:
DATE:
LOCATION:

Introduction

As Interactive Video training packages, such as *Terminal*RISK, become more widespread it is important to look at how we learn from them to enable future products to be as effective as possible. These questions are not to test your knowledge, but to try and reveal what roles different program components play in the learning process. Therefore I would be grateful if your answers were as detailed as possible - even in areas where you're not confident of your depth of knowledge it would be useful if you could write as much as you can.

- 1 Please answer this question now, before you start *Terminal*RISK. It will be asked again once you have finished today, a comparison between the answers will reveal in which areas you learnt best from *Terminal*RISK.

Please describe computerised information systems risks - what they are and how you would go about identifying them as if you had to explain them to a junior colleague.

(Remainder of the page blank)

Please complete these questions once you have finished the programme

- 2 Please describe computerised information systems risks - what they are and how you would go about identifying them as if you had to explain them to a junior colleague.

(Remainder of the page blank)

- 3 What function do you think the video served in *Terminal*RISK today. (Mark the options you particularly agree with)

- A Encourages you to complete the programme.
- B Makes the programme more interesting.
- C Helps you keep track of where you are in the programme.
- D Helps you to organise your thoughts and remember facts.
- E Clarifies principles described elsewhere in the programme.
- F The video was not helpful.
- G Other.....

4 Which sections of the video did most serve the following functions. (Mark the options you particularly agree with)

Tutorial Bytes

Neither

A	Made it clear how weaknesses could be exploited.			
B	Gave a review of what you had just done.			
C	Introduced concepts for the next stage.			
D	Furthered the story line to keep up the incentive to keep going.			
E	Helped to clarify what you had done during the tasks.			
F	Other..... ...			

5 Without reference to your notes please describe the weaknesses found in Portland's CIS?

6 Again without reference to your notes, can you remember the seven CIS risks, and if possible which parts of the 'House of Portland' represented them?

RISKS	PART OF 'HOUSE OF PORTLAND'
1	
2	
3	
4	
5	
6	
7	

7 What role(s) does the narrative play? (Mark the options you particularly agree with)

- A It made the programme more enjoyable to be working towards solving a problem, rather than just learning the principles.
- B The need to know what happens in the end encouraged you to keep going.
- C Seeing how Norman Bytes could exploit the weakness brought home the importance of risk evaluation.
- D Working alongside Ben and Laura to discover the weaknesses made you feel more able to tackle the tasks.
- E Remembering the story will help you remember the risks and the approach to identifying them.
- F You can't see any need for a narrative at all.
- G Other.....

Please leave this questionnaire with the course administrator
- Thank you for your time -

Appendix B: - Example Questionnaire Response

Pre Test

- (a) access + general access (ie locked doors... password control)
- (b) input (input entered only once completely and accurately)
- (c) processing / rejection of information to process. (info is entered and processed correctly only once - info cannot be entered more than once, rejected info is identified and entered a second time correctly only once)
- (d) organisation + management (management review rejection . exception reports 0 details are re-input correctly, exception reports are reviewed on a timely basis + appropriate adjustments are made.

Post Test

	Access -	personnel have unauthorised access to an application, eg purchase / payment or payroll
	Input -	data is input to a computer - only once, completely + accurately
Application risks	Rejection -	Once an item is rejected the correct information is not input again either correctly or timely
	Processing -	after input, this control is to ensure information is processed correctly + accurately (ie risk that processing is done incorrectly + not accurately and that this is not picked up)
	Program change	to ensure that the necessary program changes are completely and accurately executed (ie risk that this will not happen)
General risks	Organisation + mgt.	risk that management will not pick up / detect any problems with the CIS, including non review of exception reports, no review of batch controls from computer to normal controls totals.
	General access	risk that unauthorised personnel may access the CIS (control by locked doors etc).

Appendix C: Phase 1 Questionnaire

The Planet Earth - A Scientific Model

Please answer all questions as fully as possible - making a guess at an answer even when you are not sure of the correct answer.

Name: _____

Did you work with the computerised version of this?

YES / NO *Please circle*

Question 1

When we look at the moon in the night sky it has often changed shape (between a crescent and a full moon). What causes it to look a different shape?

Question 2

Please draw a simple diagram to show what might cause apparent change in the moon's shape.

Question 3

What do you think a 'lunar eclipse' is?

Question 4

What do you think are the benefits of using a model in science?

What Did You Learn.

Question 1

When we first saw the pendulum on the roundabout it appeared to swing strangely - why was that?

Question 2

What did we need to do to see what was really happening?

Question 3

How does the pendulum swinging on the roundabout relate to the pendulum in the cathedral?

Question 4

What can we learn about the earth from the pendulum in the cathedral?

Question 5

When we look at the moon in the night sky it has often changed shape (between a crescent and a full moon). What causes it to look a different shape?

Question 6

Please draw a simple diagram to show what might cause apparent change in the moon’s shape?

Question 7

Why is it that we don’t see a lunar eclipse every month? (a diagram may help you explain)

Question 8

When do we see a lunar eclipse? (a diagram will help you explain)

Question 9

Why did the planet appear to do a loop in the sky? (a diagram will help you explain)

Question 10

What do you think are the benefits of using a model in science?

About The Programme.

Question 1

What did you like about the programme?

Question 2

What was the programme about? What were you meant to learn?

Question 3

Did you feel like you knew what you were doing?

No, not at all			Half of the time				Yes fully		
1	2	3	4	5	6	7	8	9	10

Question 4

Did you feel as if you understood enough of the information?

No, not at all			About half of it				Yes completely		
1	2	3	4	5	6	7	8	9	10

Question 5

Did you find this a good way of learning?

No, not at all			Half of the time				Yes completely		
1	2	3	4	5	6	7	8	9	10

Question 6

If you saw the computerised version - how do you think this compares?

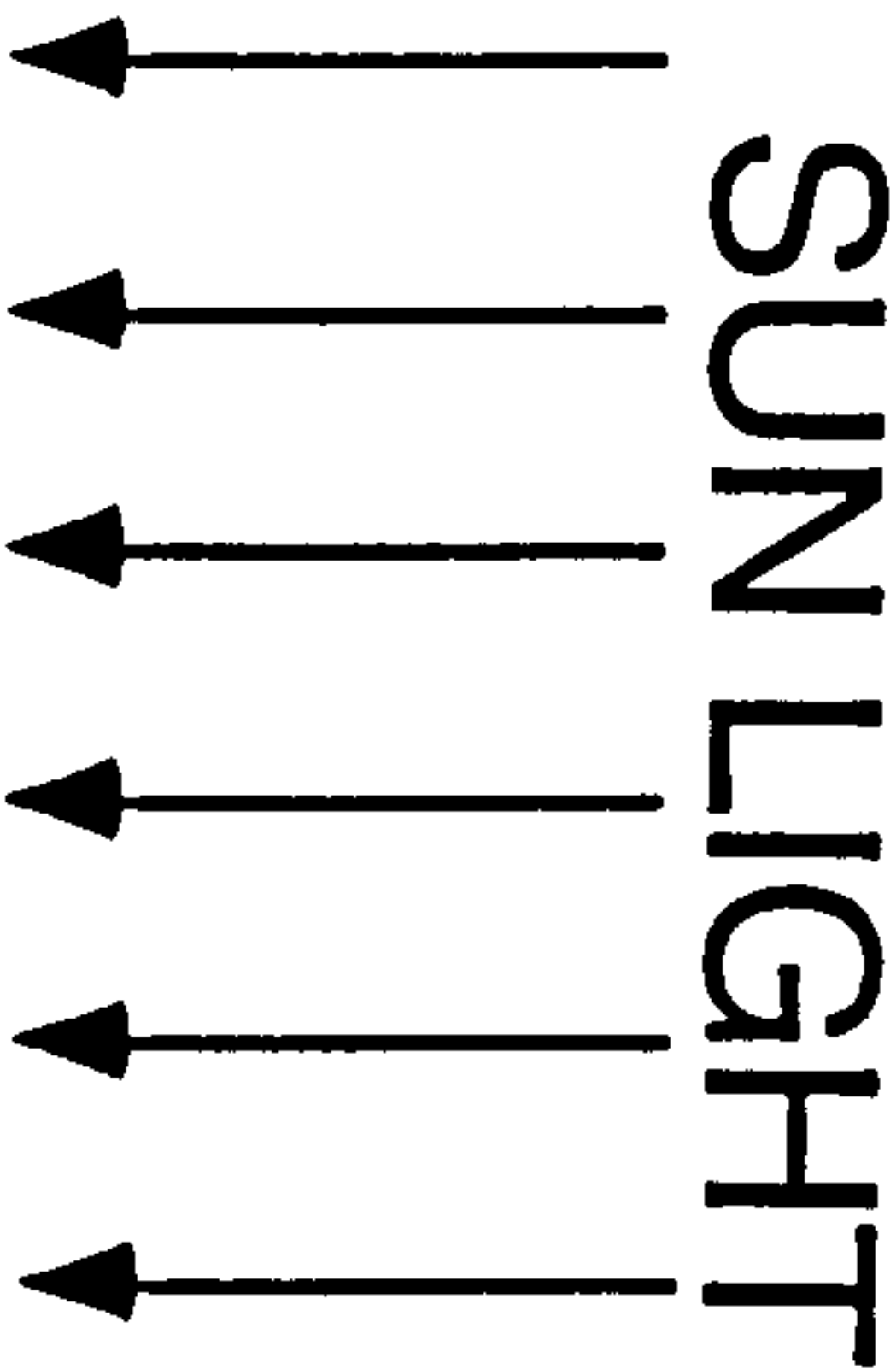
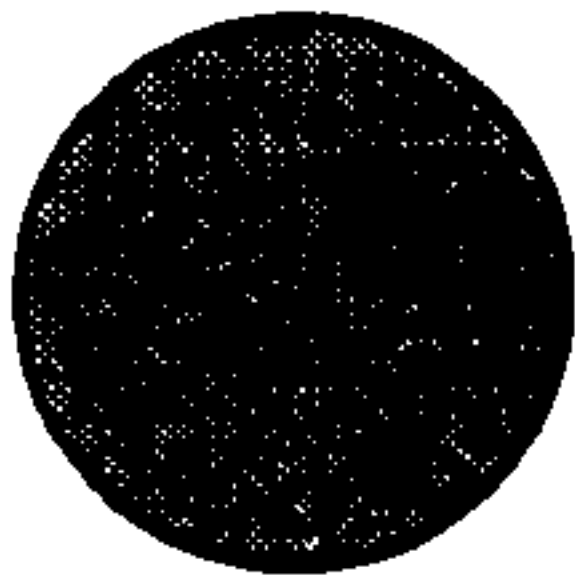
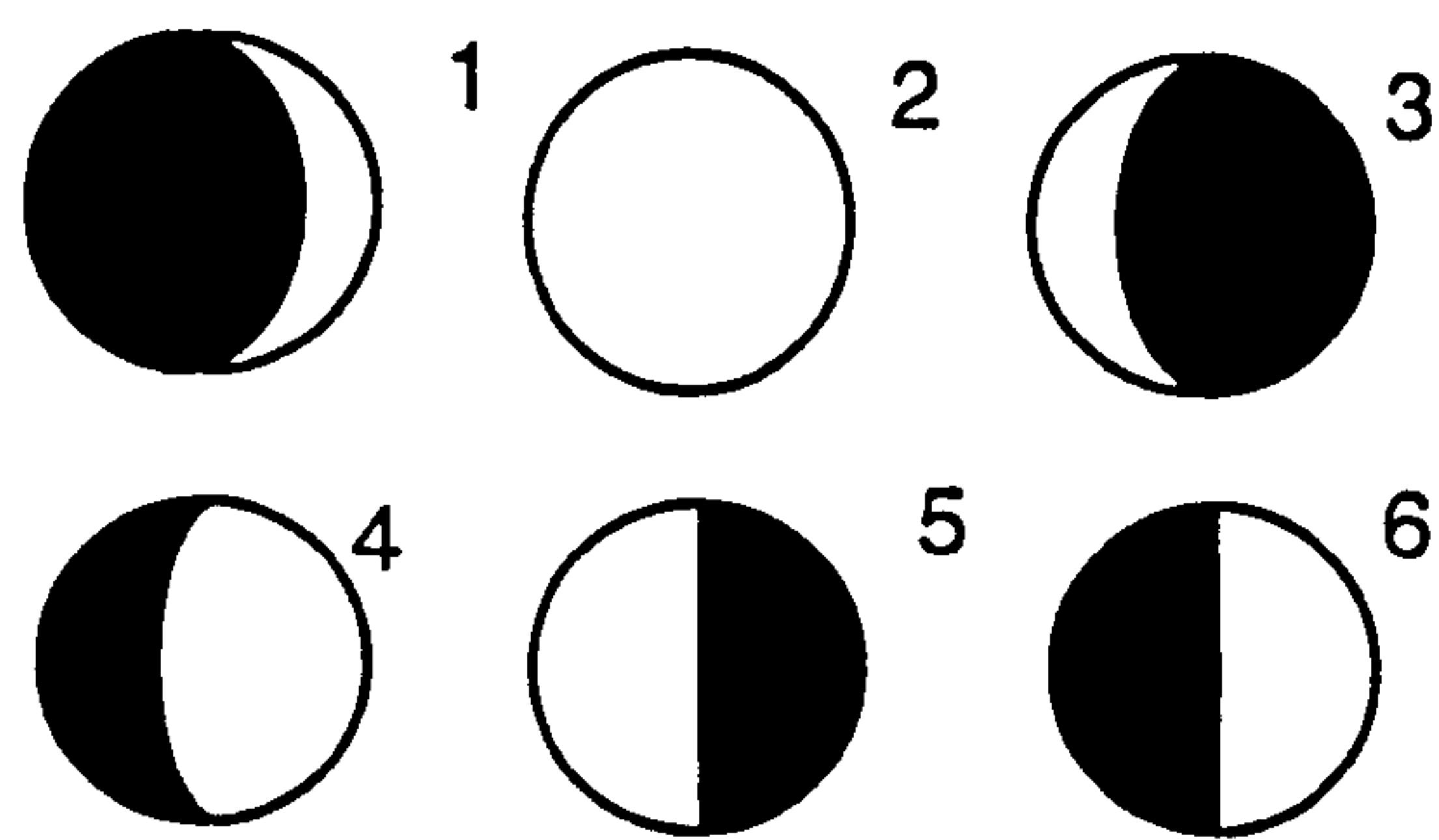
Question 7

Did you feel that the programme could have explained things better?

Question 8

Describe what changes you would make to improve the programme.

Appendix D: Phase 2 Work-Sheet



Appendix E: Phase 2 Example Data file

FILE:8/6/93datastephanie&william
START:11:31:34 am
SAVED:12:11:10 pm
CARDS VISITED ***** 0
Intro 18
contents 7
intro1 21
contents 3
about1 38
about2 36
about3 36
about4 39
about5 1
about6 3
contents 4
about1 3
about2 2
about3 1
about4 4
about5 VP VP VP 45
about6 33
contents 3
task1inst 39
task1inst2 Change Change 58
contents 9
task1 314
contents 3
task2inst 49
contents 9
task2 587
task1 24
task2 50
done 20
done2 898
control

TASK ONE ACTIVITY *****

Enter Card
Correct Correct Correct Correct Correct Correct Correct Correct
Leave Card

from task2
Enter Card

switch to task2
Leave Card

TASK TWO ACTIVITY *****

tries:0 score:0
Enter Card

tries:1 score:0
tries:2 score:0
tries:3 score:0
tries:4 score:1
tries:5 score:1
tries:5 score:0
tries:6 score:0
tries:7 score:1
tries:8 score:2
tries:9 score:2
tries:9 score:1
tries:10 score:1
tries:10 score:0
tries:11 score:0
tries:12 score:1
tries:13 score:2
tries:14 score:2
tries:14 score:1
tries:15 score:1

tries:15 score:0
tries:16 score:0
tries:17 score:1
tries:18 score:2
tries:19 score:3
tries:20 score:3
tries:20 score:2
switch to task1
Leave Card

from task1
tries:20 score:2
Enter Card

tries:21 score:3
tries:22 score:4
tries:23 score:5
Leave Card